Performance Assessment Report

Transportation 2035 Plan for the San Francisco Bay Area

December 2008

CHANGE IN MOTION

TRANSPORTATION 2035

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for the San Francisco Bay Area

Performance Assessment Report
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TRANSPORTATION
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Joseph P. Bort MeroCenter
101 Eighth Street
Oakland, CA 94607
TEL: 510.817.5700
E-MAIL: info@mtc.ca.gov
WEB: www.mtc.ca.gov

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Lisa Klein
Project Manager

Carolyn Clevenger, Sean Co, Theresa Romell, Glen Tepk, Jennifer Yeamans
Project Staff

Harold Brazil, Ben Espinosa, Shimon Israel, Chuck Purvis
Travel and Air Quality Forecasting

Peter Beeler, David Cooper, Michele Stone
Maps and graphics

CONSULTANT ASSISTANCE

Cambridge Systematics Inc.,
Project Performance Analysis

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I. Introduction: Why Measure Performance?

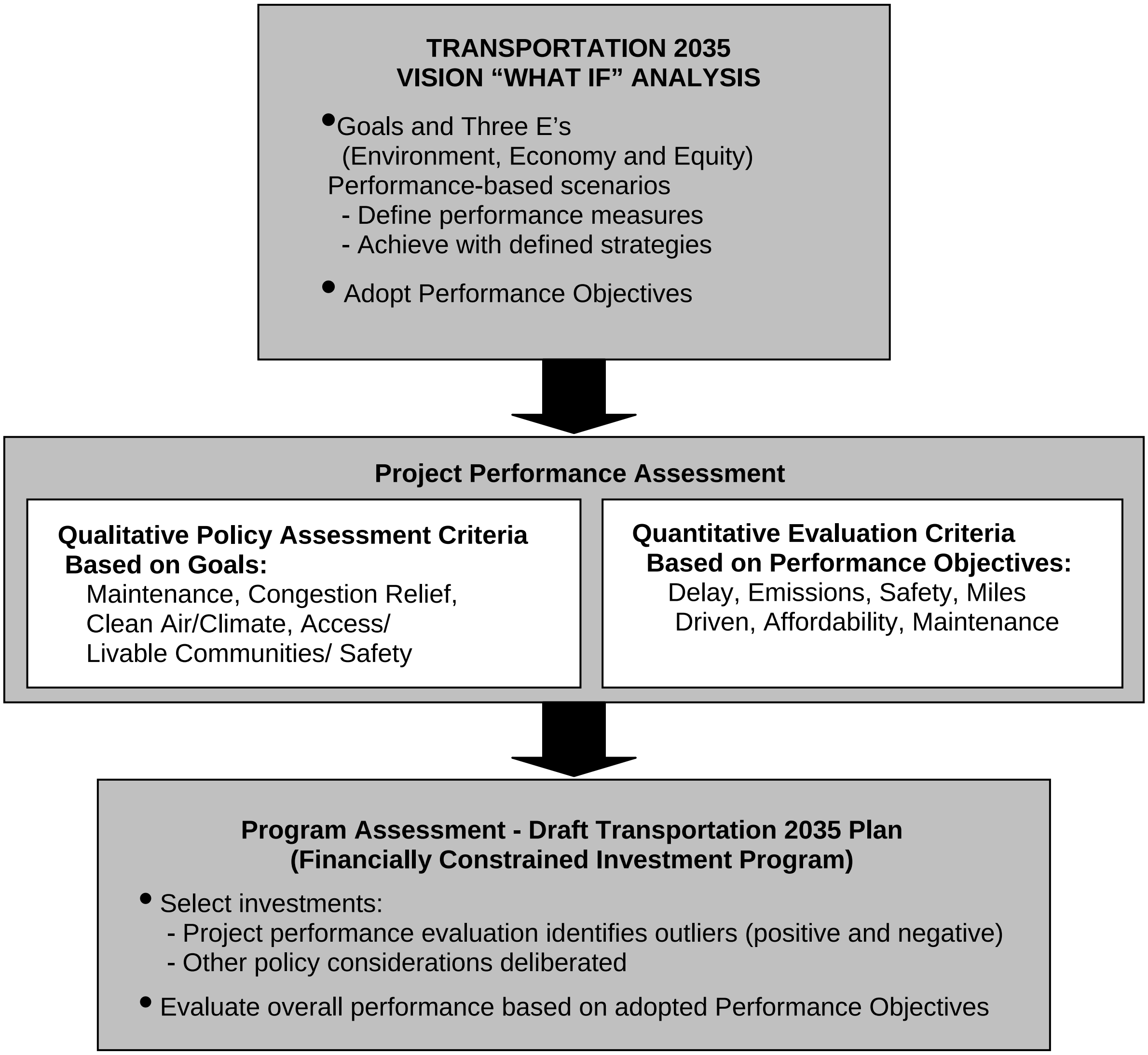
Simply stated, a performance-based planning approach focuses on the measurable outcomes of potential investments and the degree to which they support stated policies. It provides a decision-support tool to evaluate both transportation policies and investments. Performance-based planning is systematic and analytic in that it:

- expresses policy in terms of quantifiable objectives;
- relies on analytic methods to predict the impacts of different types of investments on system performance;
- sets-up an analytic framework for periodic monitoring of system performance; and
- assesses performance trends and gives us the opportunity to make adjustments in either the performance measure or the investment priority when needed.

The use of performance measures in the long-range transportation plan is not new to the Bay Area. Legislation enacted in 2002 (Senate Bill 1492, Perata) requires the Commission establish performance measurement criteria on both a project and corridor level to evaluate and prioritize all new investments for consideration in the Regional Transportation Plan (RTP). MTC conducted performance assessments for the 2001 Regional Transportation Plan in 2001 and the Transportation 2030 Plan in 2005. While the evaluation produced information that enabled comparison amongst investment options, the evaluation results were available <u>after</u> many of the key RTP investment decisions were made.

With the Transportation 2035 Plan, MTC committed to making performance information available well in advance of key policy and investment decisions. To set the stage at the start, MTC identified a set of ambitious performance objectives reflecting dramatic changes in our expectations for the region's transportation system. Past transportation plans have projected conditions such as delay and emissions will worsen considerably over time as the region grows. MTC felt it important to articulate a vision in which conditions actually improve and thus established performance objectives that call for sizable reductions in delay, emissions, and driving. To determine whether the performance objectives are achievable and what it might take in terms of investment and policy to get there, MTC started with a Vision or "What If" Analysis. A second phase of analysis comprised the Project Performance Assessment, in which MTC reviewed the cost-effectiveness of potential investments with respect to the performance objectives. To close the circle, MTC conducted a third performance assessment to measure the contribution toward the performance objectives expected with the financially constrained program of investments in the Draft Transportation 2035 Plan. The three-step performance evaluation is shown in Figure 1.

Figure 1: Transportation 2035 Performance Assessment Process



II. Performance Objectives

The Transportation 2035 Performance Objectives stem from the three E's – economy, environment, and equity – and the Transportation 2035 Goals. (See Figure 2.) The objectives are not the sole outcomes sought in a comprehensive long range transportation plan. They do, however, provide guideposts that allow us to test—through models and other analytical tools—what it might take to shape and achieve a different transportation environment 25 years in the future.

Figure 2: Transportation 2035 Performance Objectives

E's	Goals	Performance Objectives
Economy	**Maintenance & Safety**	**Improve maintenance** Local streets & roads: maintain pavement condition index of 75 or better State highways: distressed lane-miles no more than 10% of system Transit: average asset age no more than 50% of useful life and average distance between service calls of 8,000 miles. *Sources: State and local strategic plans*
		Reduce injuries and fatalities Motor-vehicle fatalities: 15% from today Bike and pedestrian injuries and fatalities: 25% each from 2000 levels *Source: California State Strategic Highway Safety Plan*
	Reliability **Freight**	**Reduce delay** 20% per capita from today 4 *Source: California's Strategic Growth Plan*
Environment	**Clean Air** **Climate Protection**	**Reduce vehicle miles traveled and emissions** Vehicle miles traveled: 10% per capita from today Fine particulate matter (PM2.5): 10% from today Coarse particulate matter (PM10): 45% from today Carbon dioxide (CO_2): 40% below 1990 levels *Sources: State regulations and laws*
Equity	**Access** **Livable Communities**	**Improve affordability** 10% reduction from today in share of earnings spent on housing and transportation costs by low and moderately-low income households *Source: Adapted from the Center for Housing Policy*

The objectives, described below in more detail, are both specific and ambitious. They establish a vision of a more livable region, in which there is less traffic delay and vehicle emissions, fewer injuries and fatalities, and a better maintained and more affordable transportation system. The objectives are "stretch" targets that serve as numerical benchmarks to measure the region's progress. For the most part, the objectives take the lead from state laws, policies and plans. MTC will report progress toward the objectives as part of the region's State of the System Report or as part of each RTP update.

While the objectives mostly take the lead from state plans and legislation, they may, with the two exceptions noted below, be changed at any time to respond to changes in Commission policy direction or circumstances. The objectives for reducing carbon dioxide and fine particulate matter (CO_2 and $PM_{2.5}$), emissions are or will be legal requirements that must be addressed in some fashion over the RTP period. The California Global Warming Solutions Act of 2006 (AB 32) requires the California Air Resources Board to establish and enforce measures to reduce statewide greenhouse gases to 1990 levels by 2020. In addition, the US Environmental Protection Agency will likely designate the Bay Area as non-attainment for the federal 24-hour $PM_{2.5}$ standard, to become effective in April 2010. State and federal agencies have yet to develop guidelines on what role the various sectors, including transportation, would have in meeting the standards. MTC may need to adjust the performance objectives when the actions necessary to meet the standards become known.

Improve Maintenance

- Maintain local road pavement condition index of 75 or greater for local streets and roads
- State highway distressed pavement condition lane-miles not to exceed 10 percent of total system
- Achieve an average age for all transit asset types that is no more than 50 percent of their useful life; and increase the average number of miles between service calls for transit service in the region to 8,000 miles.

Discussion: It costs far less to keep the existing transportation infrastructure in good condition than it does to allow it to deteriorate to the point where major rehabilitation or replacement is required.

Sources: Bay Area Partnership Local Streets and Roads Working Group's Strategic Plan and California 10-year State Highway Operation and Protection Program Plan

Reduce Collisions and Fatalities

- Reduce fatalities from motor-vehicle collisions by 15 percent from today by 2035
- Reduce bicycle and pedestrian fatalities attributed to motor vehicle collisions by 25 percent each from 2000 by 2035
- Reduce bicycle and pedestrian injuries attributed to motor vehicle collisions by 25 percent each from 2000 by 2035

Discussion: Ensuring the safety of travelers is a top priority for all government agencies engaged in transportation, whether the trip is by car, transit, bike or walking. Bicyclists and pedestrians represent 24 percent of Bay Area fatalities, which is 50 percent higher than the national average.

Source: Adapted from California Strategic Highway Safety Plan (2006)

Reduce Congestion

- Reduce per-capita delay by 20 percent from today by 2035

Discussion: The San Francisco-Oakland area has the second worst congestion in the U.S., resulting in degradation of quality of life and economic costs. In 2006, the average Bay Area commuter spent nearly 40 hours stuck in congestion.[1] About 50 percent of delay is considered "recurrent congestion", caused when demand (too many vehicles) exceed supply (road capacity). The remainder is considered "non-recurrent congestion" and is due to collisions, disabled vehicles, special events and construction.

Source: California's Strategic Growth Plan (January 2006)

Reduce Vehicle Miles Traveled (VMT)

- Reduce daily per-capita vehicle miles traveled (VMT) by 10 percent from today by 2035

The amount of driving is strongly associated with emissions including carbon dioxide and particulate matter. For this reason, state and national efforts to reduce carbon dioxide emissions often target reductions in vehicle miles driven.

Source: At the time the objectives were originally proposed, proposed state legislation (Senate Bill 375, Steinberg) called for creating aggressive targets for reducing VMT in response to global climate change. (A later version directs the California Air Resources Board to establish CO_2 targets for large metro areas.)

Reduce Emissions

- Reduce emissions of fine particulates ($PM_{2.5}$) by 10 percent from today by 2035
- Reduce emissions of coarse particulates (PM_{10}) by 45 percent from today by 2035
- Reduce carbon dioxide (CO_2) emissions to 40 percent below 1990 levels by 2035

Discussion: When inhaled, particulate matter (such as dust, tailpipe exhaust, soot and smoke) can settle deep in the lungs and pose serious health problems. Road dust is another common source of particulate matter. Bay Area does not attain the current state $PM_{2.5}$ standard and is likely to be designated in 2010 as a federal non-attainment area for $PM_{2.5}$. The Bay Area does not currently attain the state PM_{10} annual or 24-hour standards.

The Bay Area transportation sector contributes some 50 percent of CO_2 emissions and other greenhouse gas emissions. The performance target for carbon dioxide reflects requirements signed into state law in 2006, which mandates reductions to 1990 levels by the year 2020, as well as longer-term reductions called for by the Governor.

Sources: Particulate matter reductions derived by the Bay Area Air Quality Management District based on existing state standards
Carbon dioxide reductions are from California Global Warming Solutions Act of 2006 (Assembly Bill 32) and Governor Schwarzenegger Executive Order #S-3-05

[1] MTC travel forecasts.

Improve Affordability of Transportation and Housing for Low-Income Households

- Decrease by 10 percent the combined share of low-income and moderate low-income residents' earnings consumed by transportation and housing

Discussion: Bay Area families with annual incomes under $70,000 spend a combined average of 61 percent of earnings on housing (39 percent) and transportation (22 percent). A national study shows that in the Bay Area, the share of earnings low-income households spend on housing and transportation combined is about 10 percent higher than the average national share spent by these groups (due in part to the high cost of housing here).

Source: Adapted from the Center for Housing Policy report A Heavy Load: The Combined Housing and Transportation Burdens of Working Families (October 2006)

III. Vision ("What If") Analysis

TRANSPORTATION 2035
VISION "WHAT IF" ANALYSIS

- Goals and Three E's
  (Environment, Economy and Equity)
- Performance-based scenarios
  - Define performance measures
  - Achieve with defined strategies
- Adopt Performance Objectives

MTC started the Transportation 2035 Plan update with a Vision or "What if" Analysis to understand what it would take to reach the performance objectives through a combination of infrastructure investment and policy. Past analyses suggested the infrastructure investment packages would need to be ambitious and innovative and that, even so, that they were unlikely on their own to precipitate the called for performance shifts. MTC analyzed similarly ambitious policy initiatives through sensitivity analyses that assumed increased costs for driving or focused new growth in existing developed areas and near transit.

Infrastructure Investment Packages

MTC tested three hypothetical alternative infrastructure investment packages: (1) a program of freeway operations strategies; (2) a regional High Occupancy Toll (HOT) lane network with bus enhancements; and (3) extensive rail and ferry expansion. The three packages were intentionally different to reveal differences in performance. None of the packages was constrained to a financial budget, and they varied widely in total cost and scope as summarized below. See Appendix A for more detailed descriptions of the improvements assumed in each package.

Freeway Operations (also called Freeway Performance Initiative)

Capital Cost: $600 million (2007$)
Net Annual Operating Cost: $24 million

This package aims to maximize the efficiency of the roadway system while minimizing traditional expansion. The package includes the following strategies to maintain optimal vehicle speeds, reduce congestion and improve travel time reliability:

- Implementation of ramp metering along the entire freeway system. Ramp metering currently operates on 16 percent of the freeway system.
- Full deployment of the regional freeway traffic operations system (TOS) to improve incident detection and response. TOS currently operates on about 25 percent of the freeway system.
- Improved arterial operations and traffic signal coordination to balance freeway and arterial traffic.

- Closing critical gaps in the region's carpool lane network through use of shoulders by buses and short-distance and easily implemented gap closures for a total of 43 new lane miles of carpool lanes.

High Occupancy Toll (HOT) Network and Bus Enhancements

Capital Cost: $8.0 billion (2007$)
Net Annual Operating Cost: $600 million

The regional HOT network includes 790 lane miles of HOT lanes considered in the Bay Area HOT Network Study (December 2008). The system is comprised of roughly 500 miles of existing or funded carpool lanes converted to HOT lanes plus 290 miles of new HOT lanes that close gaps and extend the existing carpool lane system. Buses and qualifying carpools would use the HOT lanes free of charge; other vehicles would pay a toll to use the lanes. The toll, which would be collected electronically, would vary based on congestion levels. The number of toll-paying vehicles would be monitored and controlled through toll rates so the HOT lanes do not become overcrowded and slow down.

The package also reflects considerable enhancements to express bus services to take advantage of the HOT network. In addition, local bus and light rail improvements are included to complement and support the improved express bus and existing rail services. The improvement include bus priority treatments or upgrades to bus rapid transit with features such as signal priority, queue jumpers and bus lanes. In total, the package reflects a nearly 70 percent increase in peak period bus service hours and service miles with a 65 percent increase in bus fleet size and an 80 percent increase in total bus service hours.

Regional Rail and Ferry Expansion

Capital Cost: $64.2 billion
Net Annual Operating Cost: $1.2 billion

The rail network tested in this package reflects the services studied in the 2007 Regional Rail Plan for the Bay Area. The network includes improvements and extensions of railroad, rapid transit and high-speed rail services identified in that plan for the near, intermediate and long-term. It also includes two high-speed rail alignments – one over the Pacheco Pass and one over the Altamont Pass. Altogether, the package reflects a 300 percent increase in peak period rapid rail service hours and service miles plus a nearly 200 percent increase in peak period commuter rail service hours and service miles.

This package also includes enhancements to six existing ferry routes and seven new ferry routes consistent with the Bay Area Water Transit Authority's 2003 Implementation and Operations Plan. In total, the package reflects a 300 percent increase in peak period ferry service hours.

Pricing and Land Use Sensitivity Tests

MTC conducted two sensitivity tests on the investment packages to see how demand-based strategies could help achieve the objectives. Like the investment strategies, the pricing and land use sensitivity tests were purposely aggressive to test bold approaches; they were not developed as specific policy alternatives for consideration.

Pricing Sensitivity Test

MTC staff defined a set of user-based pricing strategies that would induce changes in travel behavior by increasing the cost of driving. The sensitivity test includes several strategies in combination:

- Carbon tax or tax on vehicle miles driven reflecting an increase in the cost of gasoline from approximately $7.50 to $9.00 per gallon in year 2035 (2008$). This has the effect of increasing auto operating costs from 23 to 28 cents per mile.[2]
- Congestion fee of 25 cents per mile for using congested freeways during peak periods. The charge was applied to freeways forecast to have volume to capacity ratios exceeding 0.90.
- Parking charges for all trips, peak period and off-peak, increased by $1.00 per hour. The surcharge was applied on top of existing parking charges in downtown San Francisco and Berkeley and was applied to trips for which no parking charge previously applied.

Table 1 below illustrates the effect of the pricing sensitivity test assumptions on a sample, 11-mile one-way commute by auto. The cumulative impact is a three-fold increase in driving cost.

Table 1: Illustrative Impact of Pricing Sensitivity Test on Work Trips*

	Baseline	Pricing Sensitivity Test
Auto operating cost	$8.60	$10.12
Congestion charge	$0	$5.50
Parking charge	$0	$8.00
Total Cost	**$8.60**	**$28.03**
Cost per mile (22 miles round trip)	**$0.39**	**$1.27**

Land Use Sensitivity Test

The Association of Bay Area Governments (ABAG) staff produced an alternative land use forecast that goes beyond the its Projections 2007 forecast[3] in both balancing jobs and housing and targeting growth in existing communities and near transit. The alternative land use forecast is first and foremost a policy forecast, as opposed to a purely market-driven forecast.

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[2] Assumptions and results for the pricing test described here differ from those in the fall 2007 Vision analysis. The fall 2007 analysis assumed lower baseline gas prices in year 2035 ($3.80/gallon) and the pricing test assumed a more dramatic increase in fuel prices (to $7.70/gallon). The fall 2007 assumptions are documented in detail in “Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Vision 2035 Analysis Data Summary”, November 2007. Full documentation of the updated assumptions is provided in “Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary” (December 2008). Appendix A summarizes several differences in assumptions between the fall 2007 and updated Vision analyses.

[3] Projections 2007 is the official forecast of population, housing, jobs, and income adopted by the Association of Bay Area Governments (ABAG). By law, MTC must use the ABAG-adopted forecast as the basis for the regional transportation plan.

Compared to Projections 2007, the alternative forecast reflects considerable shifts in regional growth to existing employment and housing centers, areas projected to have either household or employment growth, and areas with existing and/or planned transit. Table 2 summarizes how the shift in growth affects population by county. The alternative package also assumes fewer in-commuters from neighboring regions by accommodating approximately 37,000 more households within the Bay Area.[4]

Table 2: Population by County for Base Case and Land Use Sensitivity Test

		Year 2035		
County	**Year 2006**	**Projections 2007**	**Land Use Sensitivity Test**	**Percent Difference in Year 2035**
Alameda	1,518,500	1,938,600	1,946,400	0%
Contra Costa	1,031,100	1,300,600	1,226,200	-6%
Marin	253,800	283,100	293,600	4%
Napa	134,800	155,700	157,000	1%
San Francisco	798,400	956,800	1,169,300	22%
San Mateo	725,700	861,600	912,200	6%
Santa Clara	1,783,900	2,380,398	2,337,400	-2%
Solano	428,300	585,800	501,100	-15%
Sonoma	484,900	568,900	587,957	3%
Bay Area Total	**7,159,400**	**9,031,498**	**9,131,278**	**1%**

Percent difference may not be exact, due to rounding
Source: ABAG Projections 2007

Analysis Findings

MTC performed the Vision Analysis using the regional travel demand forecasting model.[5] The model estimates travel demand and behavior based on (1) where people are forecast to live, work go to school and conduct other activities such as shopping and (2) the time and cost associated with the transportation options assumed to be available. The Association of Bay Area Governments' (ABAG) *Projections 2007* comprise the detailed socio-economic and land use assumptions used for the analysis.

[4] A full report on the ABAG methodology is available upon request from ABAG.
[5] The travel demand forecasting assumptions for the Transportation 2035 Plan are documented in "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary" (December 2008). More general background information on the regional travel model can be found on the MTC web site at: http://www.mtc.ca.gov/maps_and_data/datamart/forecast/. The results reported here represent a "revised" Vision analysis conducted in fall 2008 to reflect the modeling assumptions and methodologies used for the Transportation 2035 Environmental Impact Report. The original Vision analysis was conducted in the fall of 2007. MTC shared those results at the October 2007 Fall Forum, and they are summarized in "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Vision 2035 Analysis Data Summary" (November 2007). Appendix A includes a summary of the several assumptions and methodologies updated between the original fall 2007 and updated Vision analyses.

Summary

The Vision analysis demonstrated, as we suspected from the start, that the adopted performance objectives are extremely ambitious. Four overarching lessons emerged to shape the Transportation 2035 policy platform:

1. The sheer magnitude of projected growth in population (25%) and jobs (55%) over 25 years overwhelms transportation system capacity.
2. Infrastructure alone does not generally help us reach the objectives; however, Freeway Operations is effective for congestion relief.
3. Policy approaches such as land use and pricing have much bigger effects. Pricing can be introduced in the near term, though not likely to the degree examined in the pricing sensitivity test. Focused growth can help achieve the objectives targets in longer-term.
4. Other approaches will be needed, as well. In particular, technology advances in vehicles and fuels are needed to help meet the emissions objectives. In addition, we will need to change our behavior in ways that reduce driving, for example through creating incentives to telecommute.

Details by Performance Objective

At the time of the analysis, MTC had identified three of the five sets of performance objectives: reduce congestion; reduce vehicle miles driven and emissions; improve affordability; the objectives related to safety and maintenance had not yet been identified and thus are not assessed in the Vision analysis.[6]

Reduce Congestion

Summary: In the Vision analysis, congestion reduction is the only objective achieved with the investment and basic land use and pricing policy approaches tested. It is also the only objective for which an investment package, namely the Freeway Operations package, has a marked impact.

As shown in the wedge chart below, annual delay per capita is projected to nearly double, growing from 39 to 72 hours a year in the absence of investment or policy intervention. MTC's objective to reduce annual delay per capita by 20 percent from today yields a target of 31 hours per person per year in 2035.

The Freeway Operations investment package is unique among the strategies tested in its potential to significantly reduce delay. It would cut delay per capita to 43 hours per year, achieving roughly half the sought-after reduction. Both the HOT/Bus or Rail/Ferry investment packages have comparatively limited potential to reduce delay. They would shrink annual per delay to 61 and 65 hours per person, respectively.

If no new investments are made, the pricing and land use sensitivity tests alone are projected to cut delay per person to 61 hours per year. As shown in the wedge chart, land use, pricing and the Freeway Operations package in combination are actually effective enough to reach achieve the objective, reducing delay per capita to 31 hours annually.

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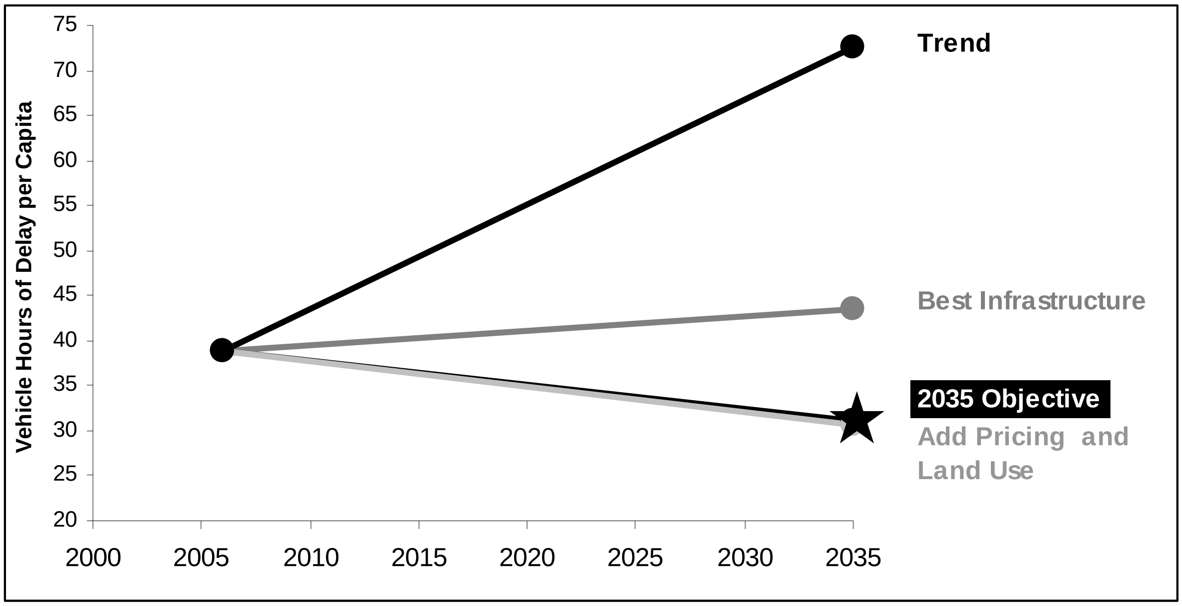
[6] The performance of the Draft Transportation 2035 Plan is assessed relative to these objectives. See Program Assessment of the Draft Transportation 2035 Investment Plan (Section V) of this report.

Note that this analysis accounts for both recurrent delay and non-recurrent delay. The transportation industry typically measures and forecasts recurrent delay, which is a direct result of the number of vehicles on the road at any given time. Recurrent delay, however, is estimated account for roughly 50 percent of the total delay travelers actually experience. Non-recurrent delay, which results from traffic accidents, construction and special events and is more difficult to measure, comprises the other 50 percent.[7]

Reduce Congestion Delay per Person



Trend, Best Infrastructure and Add Pricing and Land Use values in the chart are shown in bold font in the table below.

2035 Annual Vehicle Hours of Delay per Capita
2006 Level: **39** hours per person per year
2035 Objective: **31** hours per person per year

	Infrastructure Packages			
Policy Packages	**No New Investments**	**Freeway Operations**	**HOT & Local/ Express Bus**	**Regional Rail & Ferry**
No Policy Changes	**72**	**43**	61	65
Pricing Sensitivity	61	36	50	54
Land Use Sensitivity	61	38	53	57
Combined Pricing and Land Use	51	**31**	43	46

Reduce Vehicle Miles Traveled

Summary: None of the basic strategies tested, alone or in combination, are up to the task of reducing vehicle miles traveled (VMT) to the target level. The infrastructure packages offer

[7] See "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary" (December 2008) for recurrent and non-recurrent delay forecasts and discussion of the methodology used.

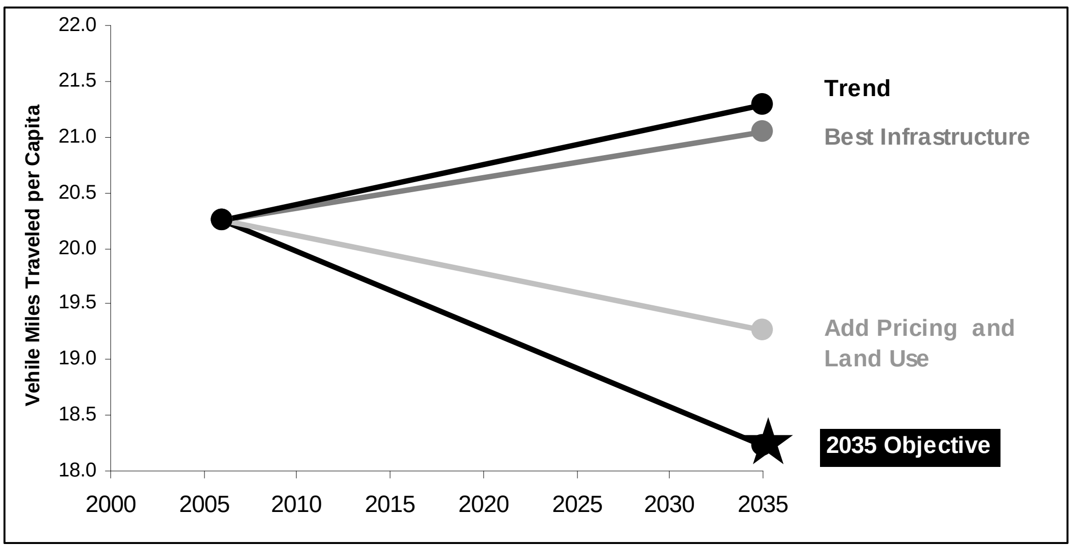
marginal reductions. Pricing and land use have a much larger effect but still fall well short of the objective.

The projected trend is growth in daily per capita VMT from 19.0 in 2006 to 21.3 in 2035. The objective is to reduce daily per capita VMT by 10 percent below today amounts to a target of 17.1 in 2035. This seemingly modest reduction is, in fact, quite difficult to achieve.

None of the three infrastructure packages make a meaningful dent in VMT per capita. The HOT/Bus and Rail/Ferry packages are projected to reduce daily VMT per capita to 21.0. The Freeway Operations package would actually increase daily VMT per capita slightly to 21.5

Land use and pricing have a much bigger effect on reducing VMT and are most effective in combination with the HOT/Bus or Rail/Ferry investment packages. Together, these measures, with either investment package, are projected to decrease VMT per capita to just over 19 per day. However, this is higher than 2006 levels and short of the objective.

Reduce Daily Vehicle Miles Traveled per Person



Trend, Best Infrastructure and Add Pricing and Land Use values in the chart are shown in bold font in the table below.

2035 Daily Vehicle Miles Traveled per Person
2006 Level: **19.0** miles
2035 Objective: **17.1** miles

	Infrastructure Packages			
Policy Packages	**No New Investments**	**Freeway Operations**	**HOT & Local/ Express Bus**	**Regional Rail & Ferry**
No Policy Changes	**21.3**	21.5	21.0	**21.0**
Pricing Sensitivity	20.6	20.7	20.3	20.3
Land Use Sensitivity	20.3	20.4	20.0	20.0
Combined Pricing and Land Use	19.5	19.6	19.3	**19.2**

Reduce Particulate Emissions ($PM_{2.5}$ and PM_{10})

Summary: These objectives are arguably the most difficult to achieve. Like most of the objectives, the land use and pricing sensitivity tests have more significant impacts than the infrastructure investments; however, all of these measures considered in combination, achieve only one sixth to one half of the reductions called for by the objectives.

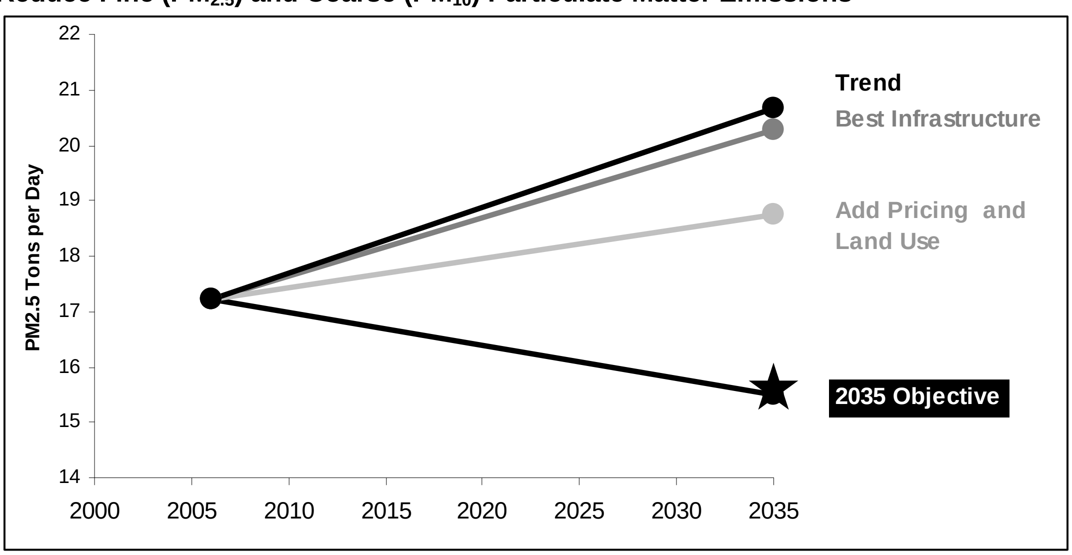
Importantly, road dust comprises 60 to 80 percent of mobile-source particulate emissions. This "re-entrained" road dust is matter kicked up by vehicles traveling on roads; it includes dust related to sanding and sweeping of the roads. Other materials comprising particulate matter include tire wear, brake wear and engine exhaust. As a result, particulate matter emissions, particularly the coarse PM_{10} particulates, are closely tied to total vehicle miles driven, and strategies effective for reducing tailpipe emissions or vehicle miles traveled per capita are generally less effective for reducing particulate matter.

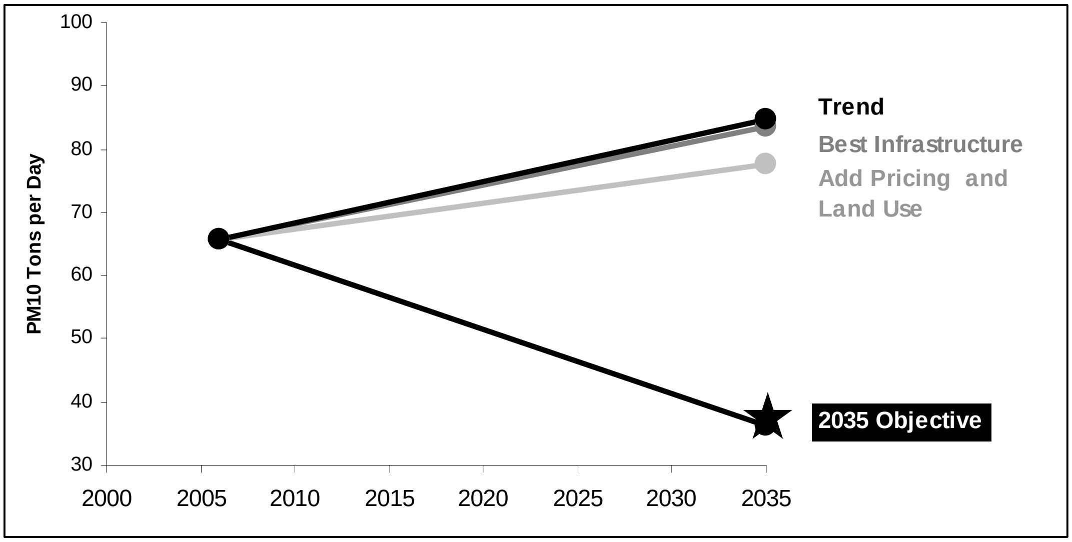
MTC projects $PM_{2.5}$ emissions from on-road mobile sources will grow from 17 tons per day in 2006 to 21 tons daily in 2035. Over the same period, PM_{10} from on-road mobile sources is projected to grow from 66 tons per day to 85 tons per day. The performance objective calls for reducing fine and course particulate matter emissions to 16 and 36 tons per day, respectively.

For the reasons listed above, the three infrastructure investment packages have limited impacts on particulate matter emissions. Each package reduces $PM_{2.5}$ by less than one ton and PM_{10} emissions by 1 to 2 tons daily in 2035.

The land use and pricing sensitivity tests are more effective than the infrastructure packages in reducing particulate emissions, but the reductions are still quite modest. The pricing test generates marginally more reductions than the land use test. The cumulative reduction from land use, pricing and infrastructure investments in combination is only 2 tons daily for $PM_{2.5}$ and 8 tons for PM_{10}, which amounts to about half and one-sixth of the reductions needed, respectively.

Reduce Fine ($PM_{2.5}$) and Coarse (PM_{10}) Particulate Matter Emissions





Trend, Best Infrastructure and Add Pricing and Land Use values in the charts are shown in bold font in the table below.

2035 Tons of $PM_{2.5}$ per Day
2006 Level: **17** tons
2035 Objective: **16** tons

Policy Packages	Infrastructure Packages: No New Investments	Freeway Operations	HOT & Local/ Express Bus	Regional Rail & Ferry
No Policy Changes	**21**	20	**20**	**20**
Pricing Sensitivity	20	20	19	20
Land Use Sensitivity	20	20	20	20
Combined Pricing & Land Use	19	19	**19**	**19**

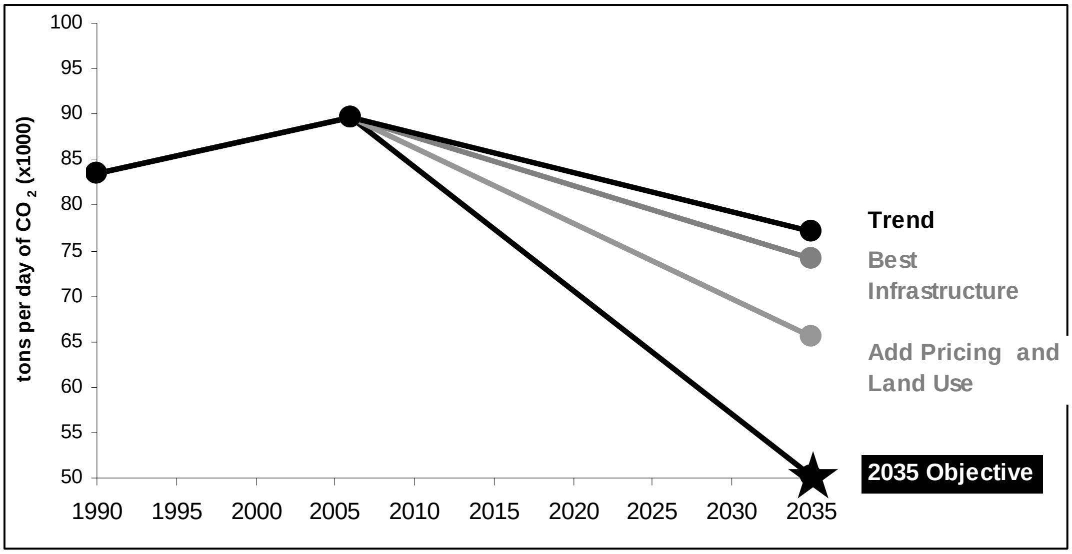
2035 Tons of PM_{10} per Day
2006 Level: **66** tons
2035 Objective: 3**6** tons

Policy Packages	Infrastructure Packages: No New Investments	Freeway Operations	HOT & Local/ Express Bus	Regional Rail & Ferry
No Policy Changes	**85**	84	**83**	**84**
Pricing Sensitivity	82	81	80	80
Land Use Sensitivity	82	82	81	81
Combined Pricing & Land Use	79	78	**77**	**78**

Reduce Carbon Dioxide Emissions (CO_2)

Summary: As with vehicle miles driven, pricing and land use contribute more reductions than investments. However, even in combination, these strategies together achieve only about half the reductions needed to reach the objective.

Reduce Carbon Dioxide Emissions



Trend, Best Infrastructure and Add Pricing and Land Use values in the chart are shown in bold font in the table below.

2035 Carbon Dioxide Emissions in Thousands of Tons per Day (US tons)
1990 Level: 97 thousand tons per day
2006 Level: 90 thousand tons per day
2035 Objective: 50 thousand tons per day

	Infrastructure Packages			
Policy Packages	**No New Investments**	**Freeway Operations**	**HOT & Local/ Express Bus**	**Regional Rail & Ferry**
No Policy Changes	**77**	**74**	75	76
Pricing Sensitivity	73	69	70	71
Land Use Sensitivity	74	70	71	72
Combined Pricing & Land Use	67	**66**	66	67

MTC projects vehicle related carbon dioxide emissions will fall from 90 thousand US tons per day in 2006 to 77 thousand tons in 2035. The reason for the decrease is improvements in fuel economy as mandated by state law (Pavley, AB 1493). Average fuel economy is expected to increase from 19.9 miles per gallon in 2006 to 32.2 miles per gallon in 2035 as tougher standards kick in and the vehicle fleet turns over. [8] The performance objective calls for reducing to 50 tons per day, which is equivalent to a 40 percent reduction from 1990 levels.

The three infrastructure packages achieve slight reductions to between 74 and 78 thousand tons per day. When pricing and land use are combined with the best investment packages, the reductions are about half of what is needed to reach the target.

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[8] This assumes 75 percent of the overall Bay Area passenger fleet is consistent with either the short-term (Phase I) or mid-range (Phase II) technology included in AB 1493. This is consistent with the California Air Resources Board's approach to evaluating the effectiveness of Pavley standards for the year 2035.

Improve Affordability of Transportation and Housing for Low and Moderately-Low Income Households

Summary: The affordability target is unique in that pricing and land use strategies have opposite effects. As with other objectives, these strategies have a far more significant impact than infrastructure investments. Focused growth policies that lead to more housing near transit reduce transportation expenditures by reducing the need to own and use cars. Policies that increase the cost of driving can have a significant impact on transportation expenditures, as the majority of low-and moderate low-income households still rely on cars for at least some trips. If pricing policies are eventually pursued, they will need to be designed to mitigate the impacts on these populations.

For purposes of this analysis, the category low and moderately-low income households includes households with annual income of $70,000 or less. These are the two lower income quartiles in the regional travel model.[9]

MTC estimates low and moderately-low income households currently spend 61 percent of their earnings on housing and transportation combined. MTC and ABAG forecasts suggest this will decrease to 59 percent in 2035, assuming housing prices keep pace with inflation. The decrease is due mainly to rising incomes and growth patterns that provide more housing close to transit, which tends to decrease overall spending on transportation. This is still above the performance objective of 55 percent.

The three infrastructure packages have no appreciable impact on household expenditures on transportation and housing because they simply do not affect travel behavior enough to translate to significant changes in transportation costs. Further, transportation investments are assumed not to impact housing costs.

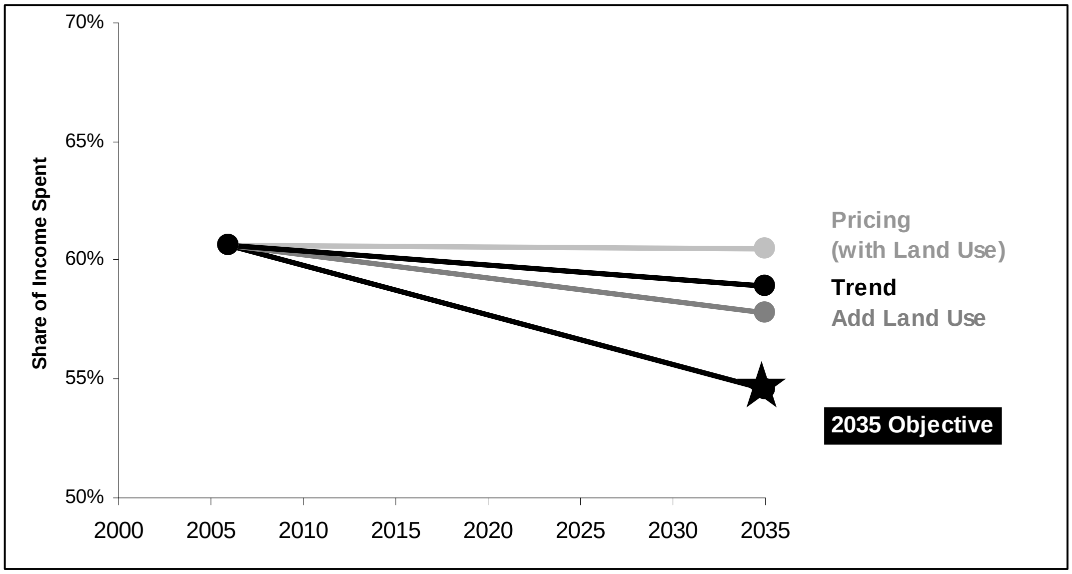
Not surprisingly, the pricing sensitivity test, which triples the cost of a typical commute, shows a significant, negative impact on affordability. This test increased the share of earnins spent by low and moderately-low income households on housing and transportation to 63 percent. On the other hand, the land use test further reduces housing costs for low-income households by locating more households close to transit and reducing auto-related expenditures. This strategy could reduce the share of income spent by low-income households on housing and transportation to 58 percent. The combined impact of the pricing and land use tests together is to hold expenditures, as a share of earnings, constant at today’s level.

The lesson to draw is that pricing strategies will need to be designed to mitigate the impact on low income households. Approaches could include direct subsidies to low-income households to offset the increased costs of driving or expanded ridesharing and transit options with or without means-based discounts. It is noteworthy that by offsetting the increased driving costs, direct subsidies may also reduce the effectiveness of pricing in achieving other targets, such as emissions and delay reductions. Clearly this impact will be more pronounced with broader

[9] See “Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary” (December 2008) for a discussion of assumptions and how expenditures were measured.

eligibility for subsidies. The Vision Analysis did not attempt to quantify impact of subsidies; however, these issues would be fully vetted in the process of designing a specific pricing policy.

Reduce Share of Household Budget Low-Income and Moderate Low-Income Households Spend on Housing and Transportation



Trend, Land Use and Pricing and Land Use values in the chart are shown in bold font in the table below.

2035 Share of Household Budget Spent on Housing & Transportation by Low and Moderately-Low Income Households (up to $70,000 household income)
2006 Level: **61** percent
2035 Objective: **55** percent

	Infrastructure Packages			
Policy Packages	**No New Investments**	**Freeway Operations**	**HOT & Local/ Express Bus**	**Regional Rail & Ferry**
No Policy Changes	**59%**	59%	59%	59%
Pricing Sensitivity	63%	62%	62%	62%
Land Use Sensitivity	**58%**	58%	58%	58%
Combined Pricing & Land Use	**61%**	61%	61%	61%

Cost Effectiveness of Infrastructure Investments

The relative cost-effectiveness of the investment packages is presented in Table 3. Cost-effectiveness measures reflect the direct public investment per reduction in the emissions and travel criteria of interest: CO_2, $PM_{2.5}$, PM_{10} vehicle miles of travel, and vehicle hours of delay. The measure reflects the annual reductions from each package in year 2035 compared to the “baseline” investment package, which includes only those projects fully funded in the next four years, as defined in the 2007 Transportation Improvement Program.

On the cost side, the measure reflects the annualized capital cost and the incremental net annual operating and maintenance (O&M) cost associated with each investment package. The annualized capital cost is the total capital cost annualized at a four percent real discount rate over the expected life of the various infrastructure components. The values used for expected life are based on industry standards, guidance from FTA, and MTC and Caltrans planning assumptions:

- Buses 14 to 18 years[10]
- BRT systems – 20 years[11]
- Rail infrastructure - 30 years
- Ferry boats 20 - years
- Technology components (Freeway Operations scenario) – 20 years
- Roadways – 20 years

The net annual O&M cost is the total annual operating and maintenance cost less any new fare revenue (or in the case of HOT lanes, toll revenue) associated with the improvement.

Of the three investment packages, Freeway Operations is the most modest in cost at $600 million for capital and $24 million a year for O&M. The cost of HOT and Bus package lies in the middle at $8.0 million for capital and $600 million a year for net O&M. And the Rail and Ferry package can be considered high-cost at $64 billion for capital and $1.2 billion a year for net O&M. Appendix A lists the major cost components of each investment package.

Two sets of cost-effectiveness metrics were calculated. The first set looks at the emissions and travel reductions associated each investment package under the "baseline" land use and pricing assumptions (i.e., no sensitivity tests). Here the comparison among alternatives is equally stark. The Freeway Operations packages is roughly 5 to 50 times more cost-effective than the HOT and Bus package and about 20 to 300 times more cost effective than the Rail and Ferry package. The difference is most pronounced when it comes to reducing delay, where the very low cost Freeway Operations package is extremely effective at 30 cents per annual hour of delay reduced, and least pronounced with it comes to reducing $PM1_0$, where none of the packages is very effective.

The second set of cost-effectiveness metrics looks at reductions with the land use and pricing sensitivity tests. While the Freeway Operations package is still the most cost-effective under these conditions and has a head start prior to the land use and pricing tests, the key thing to note is that the two transit expansion packages do catch up and close the gap. The reason is that the land use and pricing levers divert a significant number of auto trips to transit, bicycling, and walking. This set of calculations is mainly illustrative and does not reflect the full public investment as it does not reflect the cost of implementing the pricing or land use sensitivity tests.

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[10] MTC's regional transit capital priorities process calls for replacing local buses at 14 years and over-the-road coaches at 18 years.

[11] Assumes a big portion of BRT cost is for roadway infrastructure.

Table 3: Cost Effectiveness of "What If" Analysis Infrastructure Packages

Infrastructure Package Cost Summary (millions of 2007$)

	Freeway Operations	HOT & Local/ Express Bus [1]	Regional Rail & Ferry
Total Capital Cost	$ 613	$ 8,007	$ 64,222
Annualized Capital Cost (4% discount rate)	$ 45	$ 859	$ 3,721
Net Annual O&M Cost	$ 24	$ 616	$ 1,210
Total Annualized Capital and Annual O&M Cost	$ 69	$ 1,205	$ 4,931

Cost per quantity reduced, compared to 2035 with no new investments

	No Policy Changes			Combined Pricing and Land Use [2]		
	Freeway Operations	HOT & Local/ Express Bus	Regional Rail & Ferry	Freeway Operations	HOT & Local/ Express Bus	Regional Rail & Ferry
Delay (dollars per VHD reduced per year) [3]	$ 0.30	$ 12	$ 75	$ 0.20	$ 5	$ 21
Vehicle Miles Traveled (dollars per VMT reduced per year)	NA [4]	$ 1	$ 5	$ 0.01	$ 0.20	$ 0.70
$PM_{2.5}$ (thousands of dollars per ton per year)	$ 604	$ 8,365	$ 42,786	$ 103	$ 1,717	$ 7,302
PM_{10} (thousands of dollars per ton per year)	$ 620	$ 2,630	$ 11,462	$ 30	$ 459	$ 1,899
CO_2 (thousands of dollars per 1000 tons per year)	$ 63	$ 1,378	$ 8,794	$ 17	$ 302	$ 1,328

[1] Cost for HOT Network based on Bay Area HOT Network Study (December 2008).

[2] Does not reflect costs associated with implementing the Alternative Land Use (e.g., developer subsidies)

[3] Includes vehicle delay associated with recurrent and non-recurrent congestion

[4] Compared to the 2035 Baseline, the Freeway Operations package increases VMT so no cost effectiveness figure is given

IV. Project Performance Assessment

Project Performance Assessment	
Qualitative Policy Assessment Criteria Based on Goals: Maintenance, Congestion Relief, Clean Air/Climate, Access/ Livable Communities/ Safety	**Quantitative Evaluation Criteria Based on Performance Objectives:** Delay, Emissions, Safety, Miles Driven, Affordability, Maintenance

Developing performance objectives set the stage for how MTC would assess projects for consideration in the Transportation 2035 Plan. MTC conducted a project-level assessment to understand how potential long range plan investments address the Transportation 2035 goals and performance objectives (See Overview section of the Transportation 2035 Plan). In spring 2008, MTC undertook a two-part assessment composed of a quantitative assessment, to measure cost-effectiveness with respect to the performance objectives, and a qualitative policy assessment, to reflect the somewhat broader considerations embodied in the goals.

The purpose was to identify outliers – projects that most strongly support the objectives and goals and those that most notably do not. This information helped guide the Commission in making the trade-offs necessary to develop the Draft Transportation 2035 Plan, but it was not the only factor. The Commission expected to include the highest-performing projects (those both cost-effective and addressing multiple goals) and exclude the lowest-performing projects (those with benefit-cost ratio less than one and addressing only a few goals). Yet, the Commission recognized from the start that the performance assessment could not capture and weight all relevant policy considerations: local priorities might outweigh performance in some cases as a policy matter; further specialized projects, such as Lifeline Transportation assistance or Climate Protection, might perform very well with respect to one goal while lacking broad based benefits. The Commission allowed such exceptions after receiving formal explanations. Ultimately, MTC found a high level of consistency between the project assessment results and priorities expressed by the county congestion management agencies, and thus required formal explanations for only a small number of projects.

The pool of projects subject to assessment included some 700 investments submitted for consideration for the “discretionary” portion of the investment plan. Projects considered “committed” initially were not subject to evaluation because they had been approved by a previous MTC action, and by subsequent resolution, the Commission directed staff to include them in the Draft Transportation 2035 Plan. However, staff later did review all committed projects with respect to the qualitative project assessment criteria. Committed projects include those fully funded in the four-year Transportation Improvement Program or fully funded with local monies, ongoing regional operations programs (e.g., 511 traveler information, freeway service patrol, TransLink®), and the Resolution 3434 Transit Expansion Program.[12]

[12] See MTC Resolution No. 3868 for a definition of committed projects

MTC staff developed the project assessment methodologies and performance measures described below through a series of discussions with an ad hoc committee of the Bay Area Partnership.[13]

Quantitative Assessment

The quantitative assessment compares project costs and benefit. The principle measure is a benefit-cost ratio in which the benefits are defined by the Transportation 2035 Performance Objectives and are monetized based on established economic research. Additional metrics assess cost-effectiveness with respect to individual performance objectives of particular interest (e.g., cost per ton of carbon dioxide reduced). The strength of the analysis lies in identifying the outliers – the highest and lowest project performers. The analysis is not precise enough to distinguish among investments with very close benefit-cost ratios.

Though relatively small in number, higher cost projects (defined as those with cost above $50 million in 2007$) typically account for 70 to 80 percent of discretionary investment decisions in the long range plan. Thus, it is informative to evaluate the higher-cost projects quantitatively. At the same time, practical limitations preclude quantitative evaluation of each of the roughly 700 projects submitted for consideration in the Plan. For the Transportation 2035 Plan, most smaller projects are not evaluated quantitatively but are subject to the qualitative policy assessment described below. The quantitative evaluation is applied to approximately 60 projects, most of which have area-wide impacts and costs higher than $50 million. The selected projects include: new carpool lanes, high occupancy toll (HOT) lane networks, freeway-to-freeway interchange improvements, reliever routes, bus rapid transit and transit priority measures, and rail extensions and enhancements. The quantitative evaluation is also applied to regional investment programs including: Transportation for Livable Communities, the Regional Bicycle Network, Lifeline Transportation, Climate Protection Program, Freeway Performance Initiative[14], and transit and roadway capital maintenance shortfalls. (See Appendix B for the guidelines used to identify projects for quantitative evaluation.)

Because the goal is to compare projects directly and quantitatively, the same set of measures (see below) is used to evaluate all 60 projects. Transportation and air quality impacts are estimated for most projects using the regional travel demand model.[15] However, different methodologies are required to evaluate the regional investment programs, which cannot, for the most part, be

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[13] The Bay Area Partnership is the main policy body for consultation and coordination among various transportation agencies in the region (MTC, public transit operators, county congestion management agencies, city and county public works departments, ports, Caltrans, U.S. Department of Transportation) as well as environmental protection agencies. See http://www.mtc.ca.gov/about_mtc/partner.htm for more information.

[14] Based on the freeway operations strategies examined in the Vision analysis (e.g., ramp metering, traffic operations system, and arterial signal timing)

[15] More background information on the regional travel model and year 2035 travel demand forecasts can be found on the MTC web site at: http://www.mtc.ca.gov/maps_and_data/datamart/forecast/. Note that the modeling assumptions and methodologies for the Project Performance Assessment predate the updates noted in Appendix A and documented in "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary" (December 2008). The Association of Bay Area Governments' (ABAG) *Projections 2007* comprise the detailed socio-economic and land use assumptions used for the analysis. Projections 2007 is the official forecast of population, housing, jobs, and income adopted by the Association of Bay Area Governments (ABAG).

represented in the travel model. For these programs, MTC staff relied on available research for similar types of improvements. (See Appendix B.)

Quantitative Evaluation Measures

By design, the measures (see Figure 3) tie back closely to the Transportation 2035 Performance Objectives. The principal performance measure is a combined benefit-cost ratio reflecting reductions in delay (recurrent and non-recurrent), emissions and collisions. The benefits are expressed in monetary terms. For example, the monetary value of delay is tied to the average regional wage rate and that of particulate matter reflects the costs associated with its health impacts. The California Transportation Commission used a similar approach in 2007 to capture the benefits of delay and emissions reduction for projects proposed for the Corridor Mobility Improvement Account Program of the State Infrastructure Bond.

A variation on the benefit-cost ratio is calculated for the transit and roadway maintenance programs. The variation reflects public and private cost savings from performing maintenance on-time as opposed to deferring it. However, this measure does not capture the second order impacts on delay, travel time, emissions or collisions.

Several additional metrics are reported at the summary level. These include total reduction in vehicle miles traveled, cost per reduction in vehicle miles traveled, total reduction in carbon dioxide, and cost per carbon dioxide emissions reduced. Further, all of the components of the benefit-cost measure (total delay reduction, carbon dioxide emissions, particulate emissions, and collisions) are reported individually.

Cost per low-income household served is reported as a trial measure for transit projects. After considering several less-than-perfect metrics and with the input of members of MTC's Minority Citizens Advisory Committee, the Commission ultimately decided to pursue this measure to test our ability to quantify the impacts related to the Affordability Performance Objective.[16] The rationale is that low-income households well-served by transit may be able to reduce the number of autos they own, thus saving considerably on transportation expenditures. While the measure is somewhat indirect, pursuing it on a trial basis provides an opportunity to see how useful it might be. The estimate of low-income households served reflects household travel survey data on transit usage rates by income level and geography. This adjustment responds to the observation that all low-income households within walking distance will not use a given transit service, which may not serve their destinations when needed or, in some cases, may be unaffordable.

All measures are based on annualized benefits in year 2035 and annualized total costs, including capital and operating and maintenance. The methodologies used to estimate benefits (using the travel demand model) and costs are described in Appendix B as are the key assumptions and values used to monetize benefits.

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[16] Additional considerations related to affordability and access are addressed in the qualitative project evaluation. Further, MTC has conducted a separate Equity Analysis for the Transportation 2035 Plan. This analysis considers at the programmatic level a range of factors relating to regional distribution of benefits and burdens among the region's low-income and minority communities, including access to opportunities, emissions, and affordability of transportation.

Figure 3: Quantitative Project Evaluation Measures

Measures	T-2035 Performance Objective
Benefit-Cost Ratio (monetized), reflecting ▪ Recurrent delay (vehicle hours) ▪ Non-recurrent delay (vehicle hours) ▪ Transit travel time[1] ▪ Particulate matter emissions ($PM_{2.5}$ and PM_{10}) ▪ Carbon dioxide emissions ▪ Fatal and injury collisions ▪ Direct user costs (vehicle operating and, in some cases, auto ownership costs) ▪ Public and private cost savings from performing on-time maintenance[2]	Reduce Congestion Reduce Emissions Reduce Collisions and Fatalities
Reduction in vehicle miles traveled (VMT) and cost per VMT reduced	Reduce Vehicle Miles Driven
Reduction in carbon dioxide emissions and cost per ton reduced	Reduce Emissions
Cost per low-income household served by transit[3] (trial measure)	Improve Affordability

[1] For HOV and HOT projects only
[2] For maintenance programs only
[3] For transit projects only

Analysis Results

Key findings for each of the quantitative project performance measures are summarized below. In the spirit of identifying outliers, the results for each metric are presented in three to four tiers, with particular focus on the top and bottom tiers. See Appendix B for more detailed tables with the complete performance analysis results.

Benefit-Cost Ratio

As with all the measures, a small number of project stand out as high and low performers, with the vast majority of projects grouped in the middle. (See Figure 4)

High benefit-cost ratios. Just a few stand out with benefit-cost ratios in the high range, (benefit-cost ratio between 10 and 30). Four of them are low-cost freeway or transit "efficiency" projects such as the Freeway Performance Initiative (operations strategies such as ramp metering, traffic operations system), HOT lane networks with express bus, urban transit system priority measures (queue jumpers and signal priority for transit), and Van Ness bus rapid transit in San Francisco.

Figure 4: Benefit Cost Ratio

High: B/C of 10 or higher	
Transit efficiency • Muni & AC Transit transit priority measures • Van Ness bus rapid transit Roadway expansion: Route 84 widening	Freeway efficiency • Freeway Performance Initiative • HOT lanes with express bus (Santa Clara, Regional)
Medium-high: B/C between 5 and 9	
Roadway maintenance HOV Lanes • Marin-Sonoma Narrows • I-680 Contra Costa and Solano • I-80 Airbase to I-505 (Solano) Freeway efficiency: HOT lanes with express bus (Alameda)	Roadway operations/expansion • I-580 Truck climbing lanes (Alameda) • I-80 reliever route (Solano) • Jepson parkway connection (Solano) Major interchange: Route 237/US 101 Transit efficiency*:* Geary bus rapid transit
Mid-range: B/C between 1 and 4	
Transit maintenance Transit expansion/efficiency • BART to Livermore • Marin County Transit • I-80, I-580, I-680 express bus • Geneva/Harney bus rapid transit • Capital corridor expansion • MTA historic streetcar Major interchanges • I-80/I-680/Route 12 • I-580/US 101 • I-680/Route 4 • Route 237/Route 85 • Route 25/US 101/Santa Teresa Blvd. • I-680 northbound /I-580 westbound	HOV Lanes: I-80 from Carquinez Bridge to Route 37 Roadway expansion • I-80 Airbase to Route 12 • Route 12 widening • Route 92 uphill passing lane • Route 239 Brentwood/Tracy expressway • Route 152 new alignment • US 101 widening south Santa Clara County • Jepson parkway phases 1 and 2 • Widen Route 4 to San Joaquin County Line • Dumbarton Bridge access (San Mateo) Regional programs • Transportation for Livable Communities • Port Emissions/Truck Retrofit
Low: B/C less than 1	
Regional Programs • Lifeline • Regional Bike Network • Climate Protection	HOV Lanes: I-80 Red Top Rd to Route 37 Roadway • Single, direct HOV connectors/ramps • Upgrade SR4 West to freeway

Medium-high benefit-cost ratios. Slightly more projects fall in this range (benefit-cost ratio of five to nine). Carpool lane gap closures and selected roadway improvements dominate this range. Other projects in this range include roadway maintenance, Geary Boulevard bus rapid transit, and improvements to the US 101 and Route 237 interchange.

Mid-range benefit-cost ratios. Roughly half the projects evaluated fall into this range (benefit-cost ratio from one to four). It includes: most transit expansion, including some less urban efficiency projects; most freeway-to-freeway interchanges; most roadway expansion projects;

transit maintenance; Transportation for Livable Communities; and the Port Emissions/Truck Retrofit Program.

Low benefit-cost ratio. A small number of projects have benefit-cost ratios less than one. These include some specialized regional programs such as the Regional Bicycle Network, Lifeline Transportation and Climate Protection Program. Other projects in this category are quite small in scale, and the analysis may not fully capture the project benefits.

It is worth noting that the relative valuation and scale of benefits are such that the benefit-cost measure is strongly driven by reductions in delay – though the calculation also includes benefits from reductions in emissions and collisions. In many respects, the benefit-cost ratio can be considered to indicate the cost-effectiveness for reducing delay. It is then not surprising that specialized projects that do not impact delay, such as the Lifeline and Climate Protection Programs, have lower benefit-cost ratios than carpool lanes and roadway and transit efficiency projects.

Vehicle Miles Traveled (VMT)

(See Figure 5)

Most Effective/Most Cost-Effective. Two projects stand out with the largest reductions in vehicle miles driven in 2035 (200 to 800 million vehicle miles annually): HOT lanes with express bus and Transportation for Livable Communities. These projects are also among the most cost effective costing $100 to $800 per thousand vehicle miles reduced.
The HOT lane projects reduce vehicle miles traveled for two reasons. First, the projects include expanded express bus service which attracts new transit riders. Secondly, the projects close critical gaps in the carpool system, which attracts more carpools. Specifically, the regional HOT network would increase the HOV system from 500 miles to 800 miles.

Limited Impact/Less Cost-Effective. Most projects have only modest impacts on vehicle miles driven (zero to 60 million vehicle miles annually). High volume transit, such as San Francisco bus rapid transit and transit priority measures, reduce vehicle miles driven by seven million to 50 million. The Regional Bicycle Network is about equally effective, reducing vehicle miles driven by 60 million in 2035. Roadway projects that provide more direct routing, such as the I-80 reliever route, can also reduce driving modestly (in the range of six to eight millions miles per year). Some of these projects are also fairly cost-effective while others are not. Cost-effectiveness for this group ranges form $200 to $7,000 per thousand vehicle miles reduced.

Increase vehicle miles driven. Not surprisingly, most roadway expansion projects increase vehicle miles driven. For the most part, however, the increases are relatively modest, lying in the range of one million to 40 million vehicle miles in 2035. The Freeway Performance Initiative generates the largest increase in vehicle miles driven at 66 million miles in 2035.

Figure 5: Vehicle Miles Traveled (VMT)

	Millions VMT Reduced in 2035	Cost per Million VMT Reduced
Most Effective/Most Cost-Effective		
HOT networks with express bus	200 to 800	\$0.1 to \$0.5
Transportation for Livable Communities	200	\$0.5 to \$0.8
Limited Impact/Less Cost-Effective		
Regional Bike Network	60	\$1
High volume transit (e.g., transit priority, San Francisco bus rapid transit, BART to Livermore)	7 to 50	\$0.2 to \$7
Roadway projects that provide direct routing (e.g., I-80 reliever, SR84)	6 to 8	\$0.5 to \$1
Increase Vehicle Miles Driven		
Most roadway expansion projects	-1 to -40	NA
Freeway Performance Initiative	- 66	NA

Carbon Dioxide

(See Figure 6[17])

Most Effective/Most Cost-Effective. A small number of projects standout with large carbon dioxide reductions in 2035 (between 100 thousand and 600 thousand US tons per year). For comparison, 100 thousand tons represents less than 2 percent of the total estimated emissions from on-road transportation in 2035. It is equivalent to one year of electricity use by 18,000 California households.[18]

These projects also tend to be the most cost-effective for reducing carbon dioxide at \$200 to \$800 per ton carbon dioxide reduced. Two of the projects, HOT lanes and the Freeway Performance Initiative are also in the top tier for benefit-cost ratio. Two other projects, Transportation for Livable Communities and the Climate Protection Program rate much less well in terms of overall benefit-cost because they have relatively limited impact on delay.

Importantly, regional the Freeway Performance Initiative is projected to reduce carbon dioxide while increasing vehicle miles driven. This perhaps counter-intuitive result stems from the fact

[17] At this time this analysis was conducted, the California Air Resources Board could provide information for partial implementation only of the fuel economy standards called for in Pavley bill (AB 1493, 2002). Specifically, this analysis reflects fuel economy standards required by Phase I (short-term technology) but not Phase II (mid-term) technology. If the analysis were conducted with the assumptions used in the performance assessment of the Vision ("What If") and Draft Transportation 2035 Plan (Sections III and V of this report), the year 2035 emissions reductions attributable to all projects would likely be lower. For discussion of the latest fuel economy assumptions, see "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary" (December 2008).

[18] California Air Resources Board fact Sheet (October 2007)

that rates increase significantly as speeds slow due to congestion. Because the Freeway Performance Initiative is so effective at reducing congestion that the emissions increases from growth in driving are more than off-set by reductions from improved travel speeds.

Limited Impact/Less Cost-Effective. The majority of projects analyzed have relatively limited impacts on carbon dioxide, with reductions (between two thousand and 20 thousand tons per year). These projects also tend to be much less cost-effective, with costs of $1,000 to $45,000 per ton reduced. This category includes several roadway improvements that improve travel speeds to a degree that offsets carbon dioxide emissions associated with any increase in vehicle miles traveled. Examples include: I-80 reliever route in Solano County and improvements to the Dumbarton Bridge access in San Mateo County.

Increase carbon dioxide emissions. A number of roadway projects, but not all of them, are expected to increase carbon dioxide emissions in 2035. The increases lie in the range of 3 thousand to 15 thousand tons per year. These include: some carpool lane gap closures on US 101 in Marin and Sonoma counties and on I-80 in Solano County; eastbound and westbound truck climbing lanes over the Altamont Pass (I-580); improvements to the I-80/I-680/Route 12 interchange in Solano County; improvements to Route 12 in Solano County; Route 4 Bypass; and Route 4 west upgrade from expressway to freeway.

Figure 6: Carbon Dioxide Emissions

	US Tons CO_2 Reduced in 2035 (thousands)	Cost per US Ton CO_2 Reduced
Most Effective/Most Cost-Effective		
HOT networks with express bus	100 to 600	$200 - $800
Climate Protection Program	300*	$200
Freeway Performance Initiative	200	$300
Transportation for Livable Communities	100	$800
Limited Impact/Less Cost-Effective		
“Reliever” routes	10 to 20	$500 to $2,000
Transit expansion/efficiency and Selected roadway expansion/interchanges	2 to 5	$1,000 to $45,000
Increase CO_2 Emissions		
Selected roadway expansion	-3 to -15	NA

* Results are for 2015, since this is proposed as a five year program

Cost per Low-Income Household Served by Transit – Trial Measure

(See Figure 7)

This measure applies to transit projects only. Notably, the number of transit projects subject to the quantitative evaluation is small, 13 in all. The majority of transit improvements in the plan are part of MTC’s Resolution 3434 transit expansion program, considered “committed” by Commission policy, and thus are not subject to performance assessment. Further, since new

Commission policy, and thus are not subject to performance assessment. Further, since new operating funds for transit are quite limited, very few additional transit expansion projects can fit within the envelope of the financially constrained Draft Transportation 2035 Plan.

Figure 7: Cost per Low-Income Households Served by Transit*

Cost per low-income household served < $1,000	
Transit Efficiency • AC Transit priority measures • San Francisco Muni transit priority measures	• Van Ness bus rapid transit • Geary bus rapid transit Transit Expansion: I-80 express bus
Cost per low-income household served $1,000 to $5,000	
Transit Efficiency • Marin County transit priority measures • Geneva Harney bus rapid transit	Transit Expansion: San Francisco historic streetcar
Cost per low-income household served $5,000 to $40,000	
Transit Expansion • Marin County transit • I-680 express bus	• I-580 express bus • Capital Corridor expansion in Contra Costa and Solano counties
Higher than $40,000: BART to Livermore (no low-income households within walking distance of proposed alignment)	

* Transit riding households within ½ mile walking distance of transit stops or stations

Most Cost-Effective. Not surprisingly, the transit projects that serve the most low-income households at the least cost (less than $1,000 per household served) are the low-cost transit efficiency projects in urban areas. Examples, include AC Transit and San Francisco Muni transit priority measures (such as queue jumpers and transit signal priority), and San Francisco bus rapid transit routes.

Moderately Cost-Effective. The projects in this category range from $1,000 to $5,000 per low-income household served. They include low-cost transit efficiency projects in less urban environments such as Marin County, and urban transit expansion projects such as the San Francisco street car extension.

Less Cost-Effective. Transit expansion projects serving less urban areas fall into this category, which captures projects from $5,000 to $40,000 per low-income household served. Examples include new express bus routes on I-580 and I-680, Marin County transit service expansion, and expansion of the Capital Corridor rail service in Contra Costa and Solano counties.

One project, BART extension to Livermore, has no households within walking distances of the planned stations.

This trial measure appears to be of some use, though it has limitations. It is a reasonable metric for comparing relatively frequent bus service. However, by accounting only for households within walking distance, it probably underestimates benefits provided by less frequent services, including rail, for which riders are likely to take feeder transit or be dropped off. The measure would be more useful in the context of evaluating a larger number of potential investments.

Qualitative Policy Assessment

The policy assessment provides information on how projects address the Transportation 2035 Goals. This assessment complements the quantitative project performance evaluation by capturing a range of considerations that might not otherwise be addressed directly, such as whether projects serve key freight corridors, support focused growth or improve access for youth, elderly or disabled. Further, whereas MTC was able to conduct the quantitative assessment for only a subset of projects as described above, the policy assessment applied to all investments under consideration for discretionary funding.

Approach

To avoid the information overload that would have been associated with evaluating each of the more than 700 projects individually, the projects are grouped into 21 types. The qualitative evaluation criteria assess the extent to which each type supports the Transportation 2035 Goals. See Figure 8 for a list of criteria. A project type may "strongly support", "support", or be "neutral toward" the criteria associated with each goal. If a project type "strongly supports" at least one criteria for a goal, it is given a "strongly supports" for that goal.

Figure 8: Project-Level Qualitative Assessment Criteria

Transportation 2035 Goals	Criteria for Determining Support
Maintenance	• Advances maintenance of the existing transportation system
Congestion Relief (Reliability and Efficient Freight Travel)* * Includes roadway safety	• Improves freight mobility • Improves transit mobility, effectiveness or efficiency • Improves local mobility or circulation • Completes a critical transportation gap (geographic or temporal) • Institutes or enables a new user-based pricing program • Implements technology-based operations or traveler information • Improves roadway safety
Emissions Reduction	• Provides an alternative to driving alone • Improves transit mobility, effectiveness or efficiency • Marketing, education and incentive programs that encourage mode shift away from driving alone or during peaks
Focused Growth	• Located within a proposed or planed priority development area • Connects two priority development area
Access and Safety (non-motorized)* * Includes affordability for low-income households and non-motorized safety	• Provides a transit alternative to driving on a future priced facility • Provides an alternative to driving alone • Improves access for youth, elderly and disabled persons • Improves safety for pedestrians and cyclists • Reduces transportation or housing costs for low income households

Analysis Results

In presenting the analysis results, it is useful to show how many goals each of the project types addresses. (See Figure 9.) Through this lens, the projects types that address the most goals comprise the high-performing outliers, and those that address just one or two goals comprise the low-performing outliers. The Commission did not prioritize among the goals; however, in the course of making trade-offs for the Financially Investment Program, Commissioners clearly acknowledged that some project types may worthwhile even if they address only one goal well.

Figure 9: Project-Level Qualitative Assessment Summary

Project Type	Goals Met[1]	Maintenance	Congestion Relief[2]	Emissions Reduction	Focused Growth	Access & Safety
Transit efficiency and expansion	4					
Bike and pedestrian	3					
Transit oriented development	2.5					
Maintenance	2.5					
Freeway/ arterial technology	2					
High occupancy toll lanes	2					
Lifeline transportation	1.5					
Freeway-to-freeway interchanges	1.5					
Carpool lanes	1.5					
Climate change and emissions reduction	1.5					
Freeway expansion	1					
Local interchanges	1					
Arterial expansion	0.5					

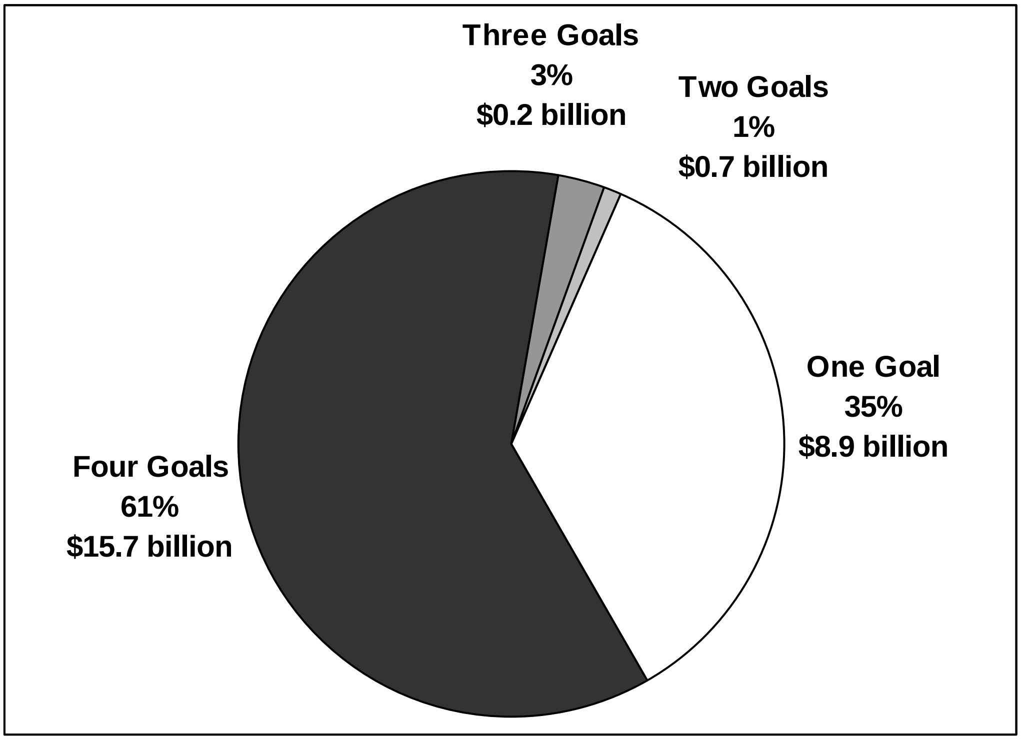
Strong Support Support

[1] This column is calculated by assigning “1” for each goal strongly supported and “½” for each goal supported.
[2] Represents the Reliability & Efficient Freight Travel Goals

Review of Committed Projects

MTC staff conducted a review of the committed projects with respect to the qualitative project evaluation criteria, which reflect the Transportation 2035 Goals. This review found that all the projects addressed at least one qualitative goal. Of capacity increasing projects with total cost of $50 million or more (2007$), the majority in number and total cost are transit projects, which meet four goals by the assessment criteria shown in Figure 9. Some 35 percent of these projects are roadway improvements or local interchanges, many of which are safety projects, and address one goal. The remaining four percent address two or three goals.

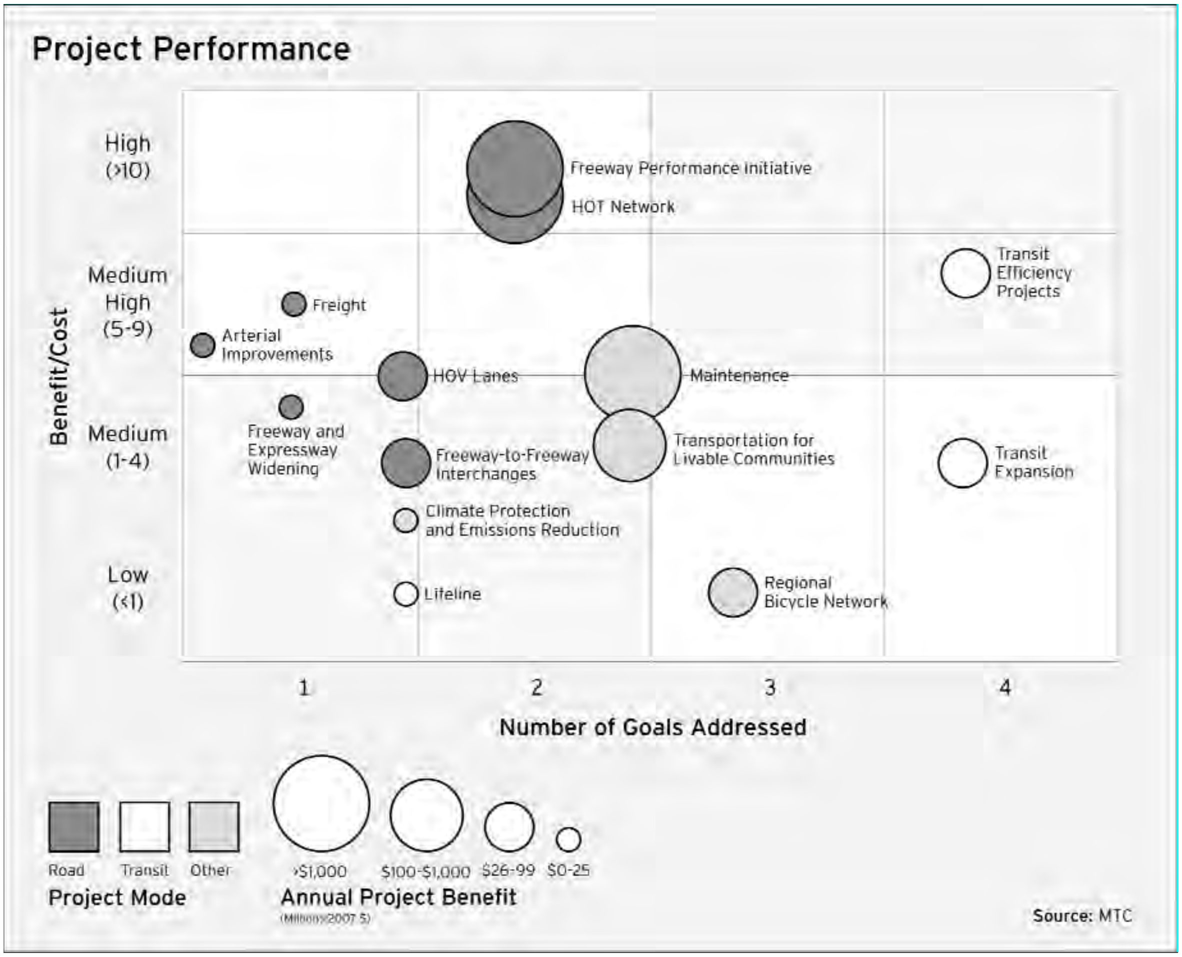
Figure 10: Committed Projects by Number of Goals Supported
Capacity Increasing, with Cost Greater than $50 billion (2007$)



Synthesizing the Results to Inform Decisions

Determining how to synthesize and use the project performance results represents a significant challenge. Figure 11, below, places the quantitative and qualitative analysis results on two axes. Each bubble represents the average result for projects of a particular type of investment. The size of the bubble indicates the total benefit in 2035. Overall high-performing outliers are located in the upper right corner. These are the types of projects, with high benefit-cost ratios and that support multiple goals, the Commission decided generally ought to be included in the Transportation 2035 Plan in fact, the Freeway Performance Initiative and Regional HOT Network were included in the Draft Plan. Low-performing outliers, project types with low benefit-cost ratios and that address few goals, are located in the lower left corner; some of these were included in the Draft Plan because they are high local priority projects or address a special need such as lifeline transportation. The Commission ultimately did use its policy discretion, after considering additional factors, to include some projects of these types in the Plan.

Figure 11: Project-Level Performance Assessment Synthesized Results



V. Program Assessment of the Draft Transportation 2035 Investment Plan

Program Assessment - Draft Transportation 2035 Plan
(Financially Constrained Investment Program)

- Select investments:
  - Project performance evaluation identifies outliers (positive and negative)
  - Other policy considerations deliberated
- Evaluate overall performance based on adopted Performance Objectives

The final step in the performance assessment is evaluation of how well the Draft Transportation 2035 Plan meets the adopted performance objectives. (See below for a summary of investments in the Draft Transportation 2035 Plan.) How far does the Draft Plan advance the region toward the objectives? How big are the remaining performance gaps? This analysis reinforces the case for bold actions and policies that can set the region on a path to begin to close the gaps.

Draft Transportation 2035 Investments

- Capital shortfalls for local roadway and transit maintenance and rehabilitation (partial funding)
- Regional High Occupancy Toll (HOT) Network
- Transportation Climate Action Campaign
- Freeway Performance Initiative
- Transportation for Livable Communities
- Regional Bicycle Network
- Resolution 3434 Transit Expansion Program
- Lifeline Transportation
- Selected County Expansion/other

Analysis Findings: How Does the Draft Transportation 2035 Plan Measure Up?

Like the other steps in the Transportation 2035 Performance Assessment, this analysis was conducted using the Regional Travel Demand Model. As required by law, ABAG's Projections 2007 are the underlying population and land use forecasts.[19]

[19] "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary" (December 2008) describes the modeling assumptions and methodologies used for this analysis. More general information on the MTC travel model can be found on the MTC web site at: http://www.mtc.ca.gov/maps_and_data/datamart/forecast/.

Summary

The results are similar to those from the "What if" analysis (see Section III). The analysis shows the Draft Transportation 2035 Plan points us down the right path – but does not take us nearly far enough. For most objectives, the Draft Plan barely "moves the needle" from the Trend. The one exception is the delay objective, for which the freeway operations strategies included in the Draft Plan are very effective. For this objective only, the Draft Plan shows significant progress, though not enough to reach the objective. These results come as no surprise as the Vision ("What If") Analysis demonstrated it will take considerably more than infrastructure investment to reach our objectives.

Policies and strategies addressing land use, pricing and technology will be required to go the extra distance needed to reach the objectives. And beyond those, the region will need to put in place programs that enable and encourage broad behavior changes. The Transportation 2035 investment plan takes a number of steps to set us down this path. These include doubling the Transportation for Livable Communities program that will support priority development areas and building the regional HOT Lanes Network, which will introduce congestion pricing throughout the region. The plan invests transit and non-motorized alternatives to encourage behavioral changes; however, the program that perhaps best recognizes the need for a multi-faceted effort is the Climate Protection Program, which includes programs to promote clean technologies as well as to enable behavioral changes through education, promotion of telecommuting and improvements to non-motorized travel options (Safe Routes to Transit, Safe Routes to Schools, and transit priority, measures).

Details by Performance Objective

Improve Maintenance

The Draft Transportation 2035 Plan reflects the need to balance objectives given limited financial resources. The cost to achieve a state of good repair for all the region's transportation assets (transit, local roadways and State highway system) exceeds the available funding. The Draft Plan reflects the difficult decision to prioritize certain elements for maintenance or maintain to a level less than the adopted objective.

For local streets and roads, the level of funding in the Draft Plan is sufficient to maintain the current state of repair. The current condition is characterized by an average pavement condition index of 63 with 22 percent of local roadways in poor or failed condition. Without this commitment, the share of local roadways in poor or failed condition would be expected to reach 41 percent. To reach the objective, an average pavement condition index of 76, we would need to provide enough funding to reduce to 13 percent the share of local roadways in poor or failed condition.

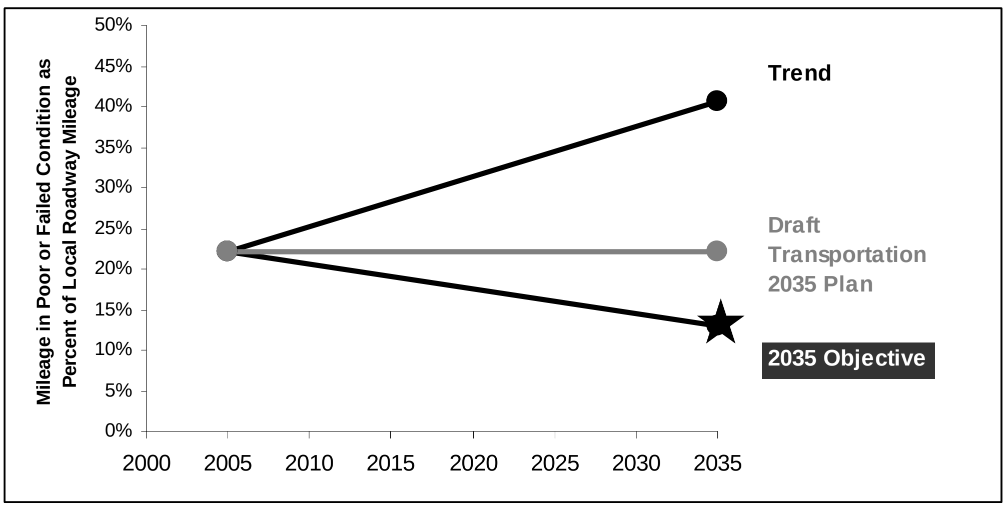
For transit, the Draft Plan commits to replace all transit vehicles on-time but requires deferring maintenance of other transit infrastructure, such as railway, stations, and maintenance facilities. This level of commitment is expected to reduce the average age of all transit assets in combination from 120 percent to 100 percent of useful life. This is just under a third of the total progress required to meet the performance objective. (If all assets were replaced on time, the average age would be 50 percent of useful life.)

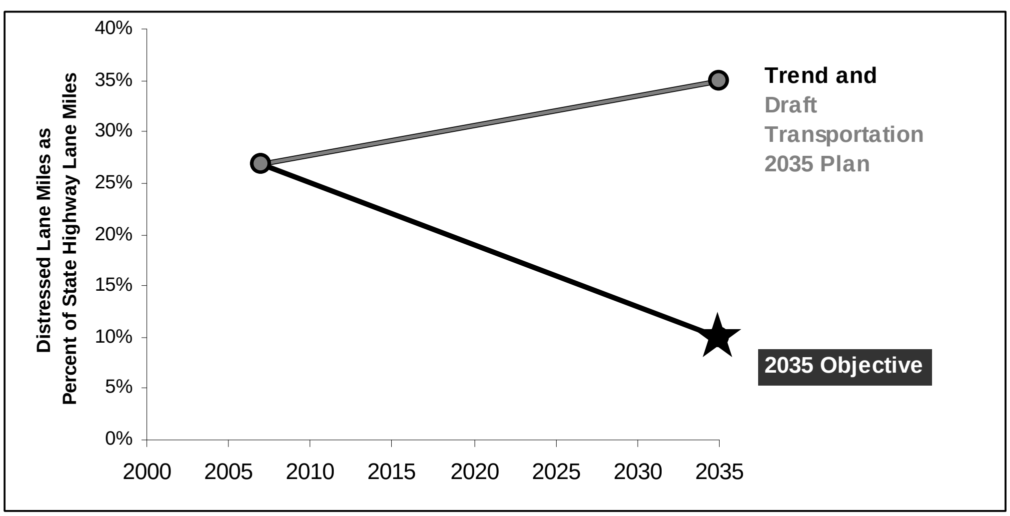
The Draft Plan includes no discretionary funding to maintain state-owned freeways and highways. As a result, the Plan makes no progress toward the objective to reduce the share of state-owned roads with distressed pavement to 10 percent. In 2035, the share of state highway and freeways with distressed pavement is expected to reach 35 percent.

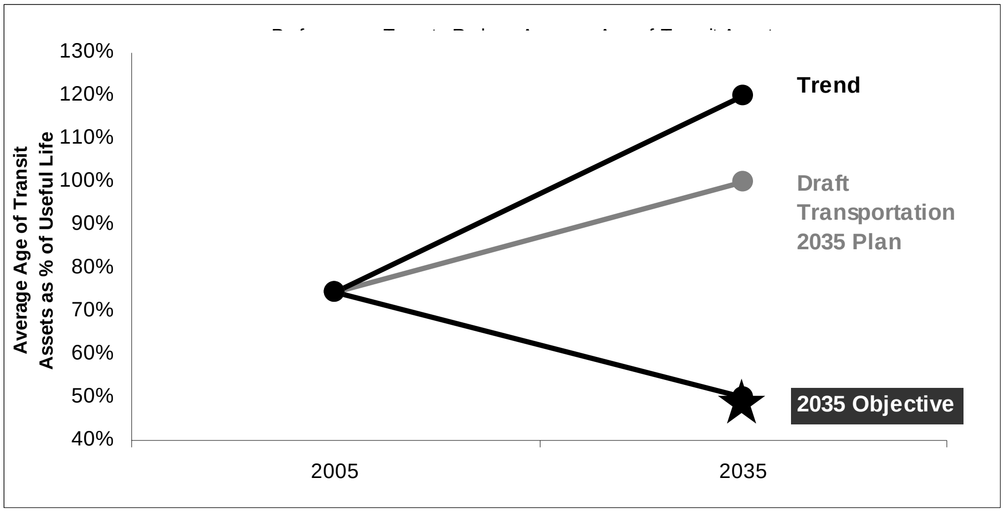
	Local Roadways Share of Roadways in Poor or Failed Condition	**State Highways Share of Roads with Distressed Pavement**	**Transit Average Age of Assets As Percent of Useful Life**
2006 Levels	22 percent	27 percent	74 percent
2035 Trend	41 percent	35 percent[2]	120 percent
2035 Draft Plan	22 percent	35 percent	100 percent
2035 Objective	13 percent[1]	10 percent	50 percent

1 This is equivalent to the adopted objective to improve the average pavement condition index to 76.

2 Distressed pavement trend in 2035 assumes the Bay Area receives its proportionate share of statewide rehabilitation funds, which after 2011 through 2018, is forecast by the state to be enough to hold distressed pavement steady at 35% of the system.



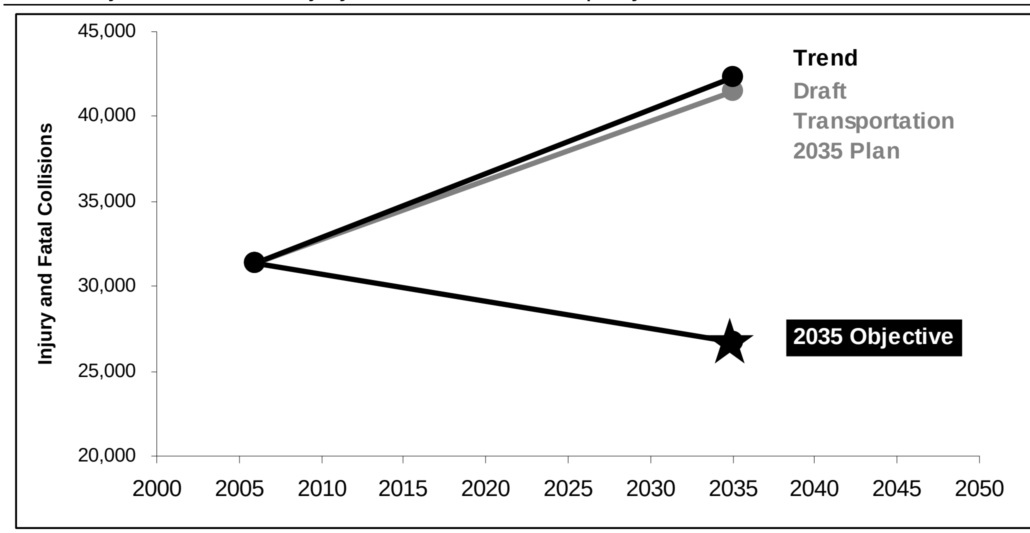




Reduce Collisions and Fatalities

This objective has three sub-parts: reduce fatalities from motor vehicle collisions; reduce bicycle fatalities and pedestrian fatalities; and reduce bicycle injuries and pedestrian injuries. While it makes a great deal of sense to monitor actual performance in these terms, our ability to forecast each metric separately is limited. As a result, this analysis considers a simplified indicator: total motor-vehicle injuries and fatalities.[20]

2006 Levels: 31,400 injury and fatal collisions per year
2035 Trend: 42,300 injury and fatal collisions per year
2035 Draft Plan: 41,500 injury and fatal collisions per year
2035 Objective: 26,700 injury and fatal collisions per year



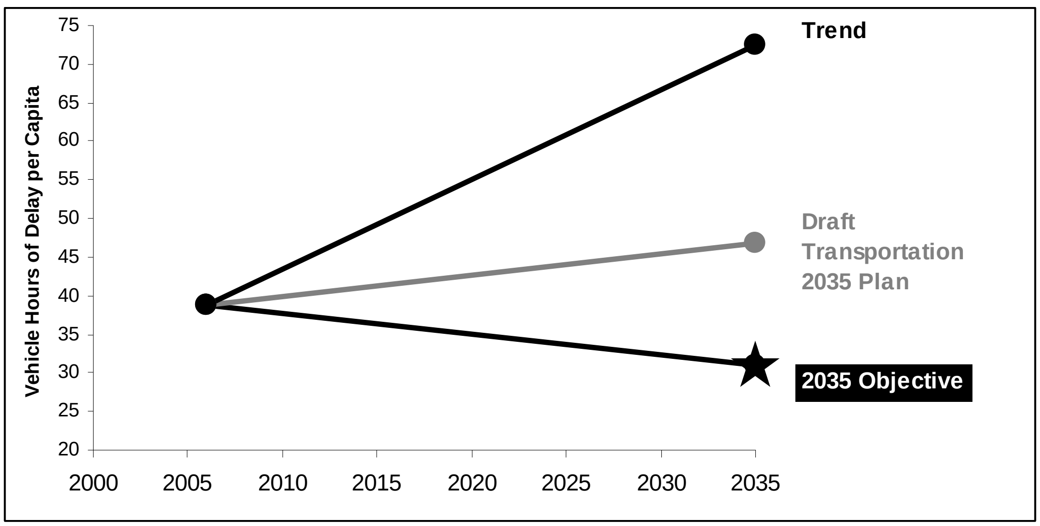
[20] The best available local data combines reflects the combined rate of injuries and fatalities as a function of vehicle miles traveled by facility type and number of lanes. There is no research on bicycle and pedestrian collision rates as a function of these or other factors captured in the regional travel demand model; thus we do not have a good basis to forecast bicycle and pedestrian injuries or fatalities.

The Draft Transportation 2035 is forecast to reduce annual motor vehicle injuries and fatalities very slightly to 41,500. This is well above current levels and a far cry from the objective to reduce fatalities from the trend of 43,300 to 26,700, 15 percent below today's level. The collision forecast is largely a function of the total vehicle miles traveled forecast. Thus, the Draft Plan's projected impact on collisions maps closely to its projected impact on vehicle miles traveled. (See below.)

Reduce Congestion

The Draft Transportation 2035 Plan is expected to reduce freeway delay per person from 72 hours a year to 47 hours a year. This is largely a result of the Freeway Operations strategies in the Draft Plan. As shown in the "what if" scenarios (see Section III of this report), strategies such as freeway ramp metering, changeable freeway message signs and coordination of traffic signals along adjacent arterials can significantly reduce delay. Even this impressive achievement falls short of the performance objective to reduce congestion to 31 hours per person per year.

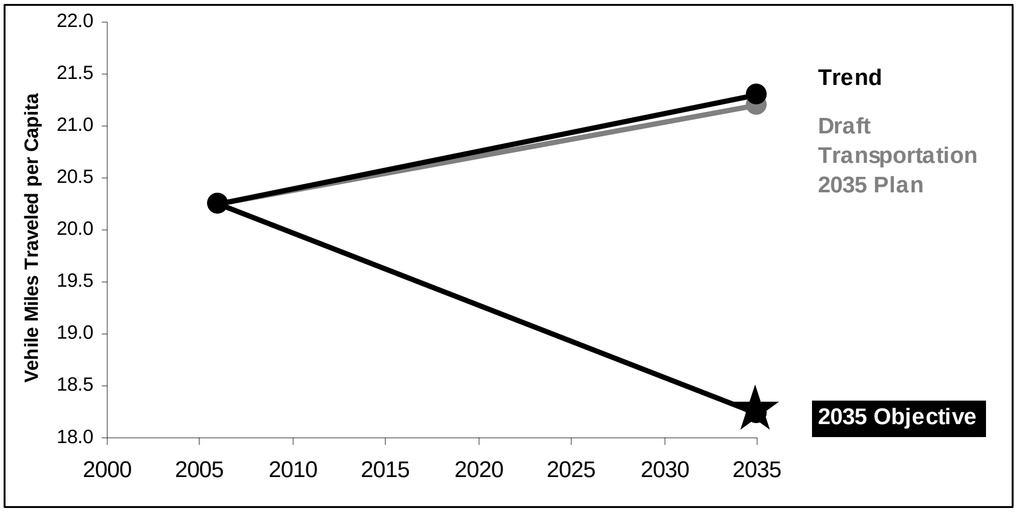
2006 Levels: 39 hours of delay per person per year
2035 Trend: 72 hours of delay per person per year
2035 Draft Plan: 47 hours of delay per person per year
2035 Objective: 31 hours of delay per person per year



Reduce Vehicle Miles Traveled

Of all the objectives, the aim to reduce vehicle miles traveled perhaps best illustrates the limits of infrastructure investments. The Draft Transportation 2035 Plan barely makes a dent in driving, reducing daily vehicle miles traveled per person from 20.3 to 20.2, which is considerably higher than the objective of 17.1 vehicle miles per person.

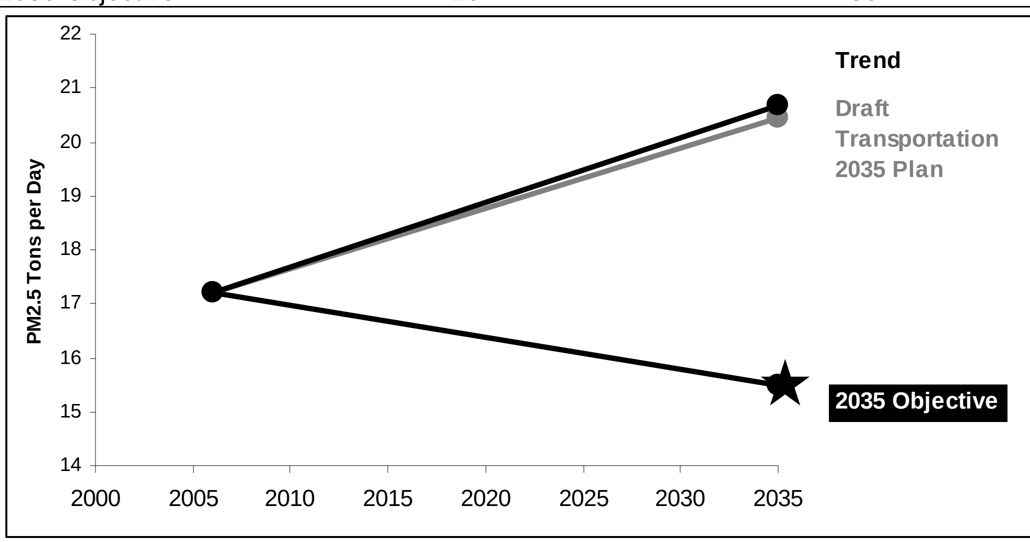
2006 Levels: 19.0 vehicle miles traveled per person per day
2035 Trend: 21.3 vehicle miles traveled per person per day
2035 Draft Plan: 20.2 vehicle miles traveled per person per day
2035 Objective: 17.1 vehicle miles traveled per person per day

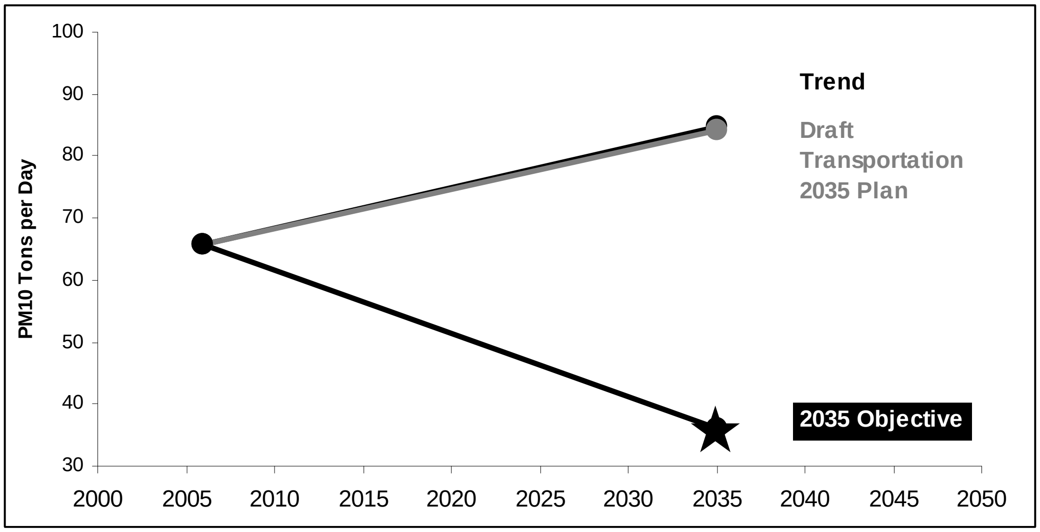


Reduce Particulate Emissions

Similarly, the Draft Transportation 2035 Plan has only a marginal impact on particulate matter emissions. The Draft Plan reduces fine particulate matter ($PM_{2.5}$) and coarse particulate matter (PM_{10}) by each about one ton per day. These reductions are about one-fifth of that needed to reach the objective for fine particulate emissions and only one-fiftieth that needed to reach to objective for coarse particulate emissions.

	Fine Particulates ($PM_{2.5}$) tons per day	**Coarse Particulates (PM_{10}) tons per day**
2006 Levels	17	66
2035 Trend	21	85
2035 Draft Plan	20	84
2035 Objective	16	36

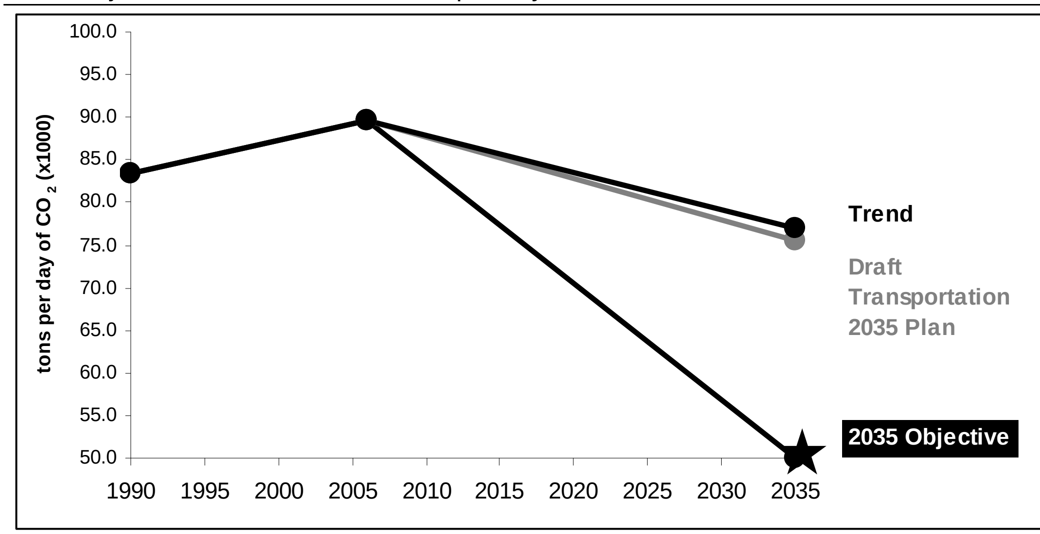




Reduce Carbon Dioxide Emissions

The future trend for transportation-related carbon dioxide emissions moves in the right direction but largely as a result of improvements in engine technology, as mandated by fuel economy standards in State law, rather than infrastructure investments. Even with $31.1 billion invested in transit expansion and operations, the Draft Transportation 2035 Plan is projected to decrease daily carbon dioxide emissions in year 2035 from 77 thousand US tons to 76 thousand tons – just 2 percent. By comparison, a 35 percent reduction is needed to reach the target of 50 thousand tons per day.

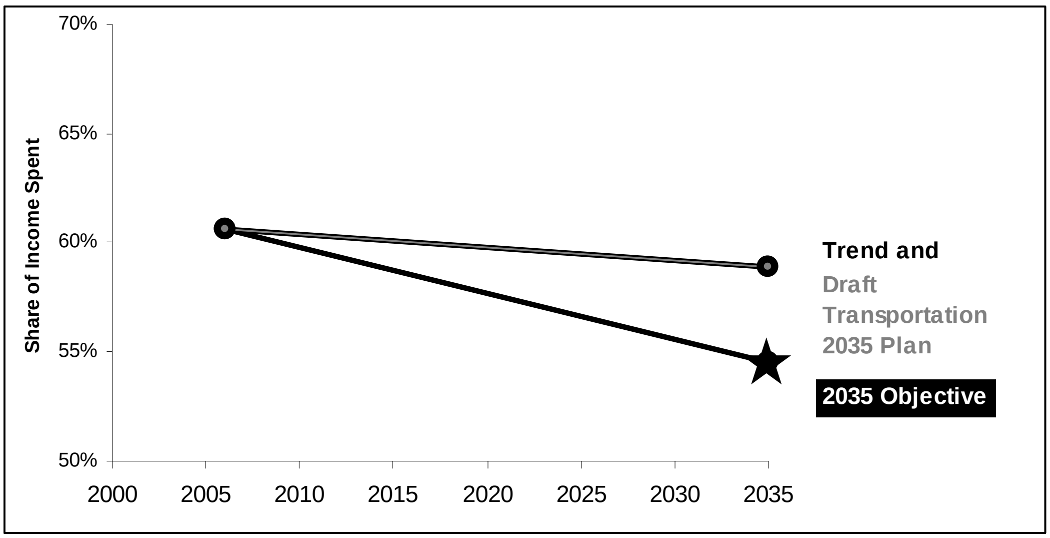
2006 Levels: 90 thousand US tons per day
2035 Trend: 77 thousand US tons per day
2035 Draft Plan: 76 US thousand tons per day
2035 Objective: 50 US thousand tons per day



Improve Affordability of Transportation and Housing for Low-Income Households

The "What if" Vision analysis demonstrated that infrastructure investment has no appreciable impact on the share income low-income households spend on transportation and housing. Pricing strategies and land use policies have much larger effects, but those are not captured in this assessment of the Draft Transportation 2035 Investment Plan. Thus, it is no surprise to find low-income households spend the same share of their income on housing and transportation in the Draft Plan as they would under the Trend.

2006 Levels: 61 percent of budget spent on housing and transportation
2035 Trend: 59 percent
2035 Draft Plan: 59 percent
2035 Objective: 55 percent



Comparison of Draft Transportation 2035 Plan to "What If" Scenario Assessment

Two final questions worth asking are: (1) how the Draft Transportation 2035 Plan performs in comparison to the best of the infrastructure packages tested in the "What If" assessment summarized in part III of this report; and (2) whether land use and pricing policies have similar impacts when combined with the Draft Plan as they did with the best of the infrastructure packages. Recall that the three investment packages we tested were not financially constrained, while the total investment in the Draft Plan is limited to expected revenues over the 25-year planning period. (For a review of the investment packages and pricing and land use test assumptions, see Part III of this report.)

Table 4 shows the Draft Plan performs very similarly to the best of the "What If" Analysis investment packages. Specifically, the Draft Plan offers reductions within one to five percent of the best investment package for each of the objectives. The Draft Plan offers slightly less reduction than the HOT/Bus investment package, the best performer in the "What If" Analysis with respect to vehicle miles traveled and carbon dioxide; this may be due to the fact it includes considerably less transit service. This small difference is insignificant when compared to the

Table 4: Comparison of Draft Transporation 2035 Plan and "What If' Investment Packages

Projected Values	Year 2035 Trend	Year 2035 Objective	Year 2035 Investment	Year 2035 Investment + Pricing + Land Use
VHD/Capita (annual)				
Vision (investment = Freeway Operations)	72	31	43	31
Transportation 2035 Plan			47	31
VMT/Capita (daily)				
Vision (investment = HOT/Bus)	21.3	18.2	21.0	19.3
Transportation 2035 Plan			21.2	19.4
CO_2 (thousands of US ons/day)				
Vision (investment = HOT/Bus)	77	50	74	66
Transportation 2035 Plan			76	67
$PM_{2.5}$ (tons/day)				
Vision (investment = HOT/Bus)	21	16	20	19
Transportation 2035 Plan			20	19
PM_{10} (tons/day)				
Vision (investment = HOT/Bus)	85	36	83	77
Transportation 2035 Plan			84	78

Percent Change	Change Needed to Meet Objective (Trend vs. Objective)	Impact of Investment (Trend vs. Investment)	Impact of Investment + Land Use + Pricing (Trend vs. Investment + Land Use + Pricing)
VHD/Capita (annual)			
Vision (investment = Freeway Operations)	-57%	-40%	-57%
Transportation 2035 Plan		-35%	-57%
VMT/Capita (daily)			
Vision (investment = HOT/Bus)	-15%	-1%	-9%
Transportation 2035 Plan		0%	-9%
CO_2 (thousands of US tons/day)			
Vision (investment = HOT/Bus)	-35%	-4%	-14%
Transportation 2035 Plan		-1%	-13%
$PM_{2.5}$ (tons/day)			
Vision (investment = HOT/Bus)	-24%	-5%	-10%
Transportation 2035 Plan		-5%	-10%
PM_{10} (tons/day)			
Vision (investment = HOT/Bus)	-58%	-2%	-9%
Transportation 2035 Plan		-1%	-8%

overall reductions required to meet the ambitious performance objectives in 2035. The Draft Plan, like the "What If" investment packages offers less than 10 percent of the total reductions needed to meet the objectives to reduce driving and emissions. The bright spot is the delay objective, for which the Draft Plan, which includes substantial investment in freeway operations, achieves about two-thirds of the needed reductions.

Similarly, land use and pricing policies are projected to have comparable effects when combined with the Draft Transportation 2035 Plan as with the best of the previously tested investment packages. The impact of these strategies, when combined with the Draft Plan, is within one percent of their impact when combined with the best of the "What If" investment packages.

Conclusions

The findings from the performance assessment of the Draft Transportation 2035 Plan strongly reinforce those from the "What If" assessment at the start of the plan update:

1. The Draft Plan performs better than the trend, but
2. Infrastructure investments alone do not help us progress meaningfully toward the objectives.
3. Land use and pricing are critical policy tools.
4. Further, the type and magnitude of infrastructure investments have relatively insignificant impacts on performance compared to the potential of land use and pricing.

It is also true, however, that the performance analysis described here does not fully account for the steps required to make land use and pricing policies successful – from garnering public and political backing to providing supporting infrastructure. Experience demonstrates the public demand for attractive alternatives (typically transit) when congestion road pricing is introduced. Further, land use and pricing policies have potential to generate tremendous growth in transit and non-motorized trips; our transportation system must be equipped to serve this demand.

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Transportation 2035 Plan
Performance Assessment Report
December 2008

Appendix A: Vision ("What If") Analysis for the Transportation 2035 Plan – Technical Background

Table of Contents

1. Vision ("What If") Infrastructure Investment Packages

MTC tested three separate infrastructure investment packages in the Vision (or "What If") analysis:

(1) Program of freeway operations strategies;
(2) Regional High Occupancy Toll (HOT) lane network with bus enhancements; and
(3) Extensive rail and ferry expansion.

These are described below and illustrated in the maps and project lists that follow.

Freeway Operations (also called Freeway Performance Initiative)

Capital Cost: $600 million (2007$)
Net Annual Operating Cost: $24 million (2007$)

This package aims to maximize the efficiency of the roadway system while minimizing traditional expansion. The package includes the following strategies to maintain optimal vehicle speeds, reduce congestion, respond quickly to incidents and improve travel time reliability:

- Implementation of ramp metering along the entire freeway system. Ramp metering currently operates on 16 percent of the freeway system. (See Figure A-1.)
- Full deployment of the regional freeway traffic operations system (TOS) to improve incident detection and response. TOS currently operates on about 25 percent of the freeway system. (See Figure A-2.)
- Improved arterial operations and traffic signal coordination to balance freeway and arterial traffic.
- Closing critical gaps in the region's carpool lane network through use of shoulders by buses and short-distance and easily implemented gap closures for a total of 43 new lane miles of carpool lanes. The network of existing carpool lanes and those with committed funding[1] extends 500 lane miles (See Figure A-3.)

High Occupancy Toll (HOT) Network and Bus Enhancements

Capital Cost: $8.0 billion (2007$)
Net Annual Operating Cost: $600 million (2007$)

The regional HOT network includes 790 lane miles of HOT lanes considered in the Bay Area HOT Network Study (December 2008). The system is comprised of roughly 500 miles of existing or funded carpool lanes converted to HOT lanes plus 290 miles of new HOT lanes that close gaps and extend the existing carpool lane system.[2] Buses and qualifying carpools would use the HOT lanes free of charge; other vehicles would pay a toll to use the lanes. The toll, which would be collected electronically, would vary based on congestion levels. The number of

[1] Projects fully funded in the region's 2007 Transportation Improvement Program (TIP).
[2] HOT Network costs have been updated to be consistent with the HOT Network included in the Draft Transportation 2035 Plan, as documented in the December 2008 HOT Network Study.

toll-paying vehicles would be monitored and controlled through toll rates so the HOT lanes do not become overcrowded and slow down. (See Figure A-4.)

The package also reflects considerable enhancements to express bus services to take advantage of the HOT network and serve the morning and afternoon peak periods.[3] The additional service supplies are estimated to be: 980,000 service hours, 21,340,000 vehicle miles, and 670 expansion buses. The regional express bus service improvements are accompanied by supporting infrastructure improvements such as new park-and-ride lots, transit centers, and direct HOV/HOT access ramps.

In addition, local bus and light rail improvements are included to complement and support the improved express bus and existing rail services. Much of the improvement is actually enhancing existing services, primarily through increasing service frequency. Some new "Rapid Bus" routes and Bus Rapid Transit (BRT) are included; however, no light rail extensions were proposed. For local buses, the general approach was to identify major trunk corridors, and to improve peak and off-peak service levels of the local bus transit that operate on them. The improvements include upgrading services to BRT or Rapid status and assuming complementary transit priority measures or speed protection measures, such as signal priority, queue jumpers, bus lanes, etc.. The improvements to local bus services are estimated to add: 5,280,000 service hours, 73,000,000 service miles, and 1,400 buses. The improvements to light rail services are estimated to add: 245,000 service miles, 3,760,000 service hours, and 97 rail cars. (See Figure A-5 and Figure A-6 for a comparison of service frequency in the base case and this investment package. Figure 7 shows the routes with transit priority treatments. Table 1 lists the "Rapid Corridors".)

In total, this investment package reflects a nearly 70 percent increase in peak period bus service hours and service miles with a 65 percent increase in bus fleet size and an 80 percent increase in total bus service hours. The light rail improvements increase service hours by 33 percent, service miles by 45 percent, and fleet size by 35 percent.

Regional Rail and Ferry Expansion

Capital Cost: $64.2 billion (2007$)
Net Annual Operating Cost: $1.2 billion (2007$)

The rail network tested in this package reflects the services studied in the 2007 Regional Rail Plan for the Bay Area. The network includes improvements and extensions of railroad, rapid transit and high-speed rail services identified in that plan for the near, intermediate and long-term. It also includes two high-speed rail alignments – one over the Pacheco Pass and one over the Altamont Pass. Altogether, the package reflects a 300 percent increase in peak period rapid rail service hours and service miles plus a nearly 200 percent increase in peak period commuter rail service hours and service miles. (See list of improvements in Table A-2.)

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[3] The express bus service improvements were defined through consultation with Bay Area Transit operators as well as by previous and current planning efforts, such as MTC's Bay Area Transportation Blueprint for the 21st Century (2000), the Regional Rail Plan (2007), and the Freeway Performance Initiative (see Package #1).

This package also includes enhancements to six existing ferry routes and seven new ferry routes consistent with the Bay Area Water Transit Authority's 2003 Implementation and Operations Plan. In total, the package reflects a 300 percent increase in peak period ferry service hours. (See list of services in Table 3.)

Figure A-1: Freeway Operations Package - Ramp Metering

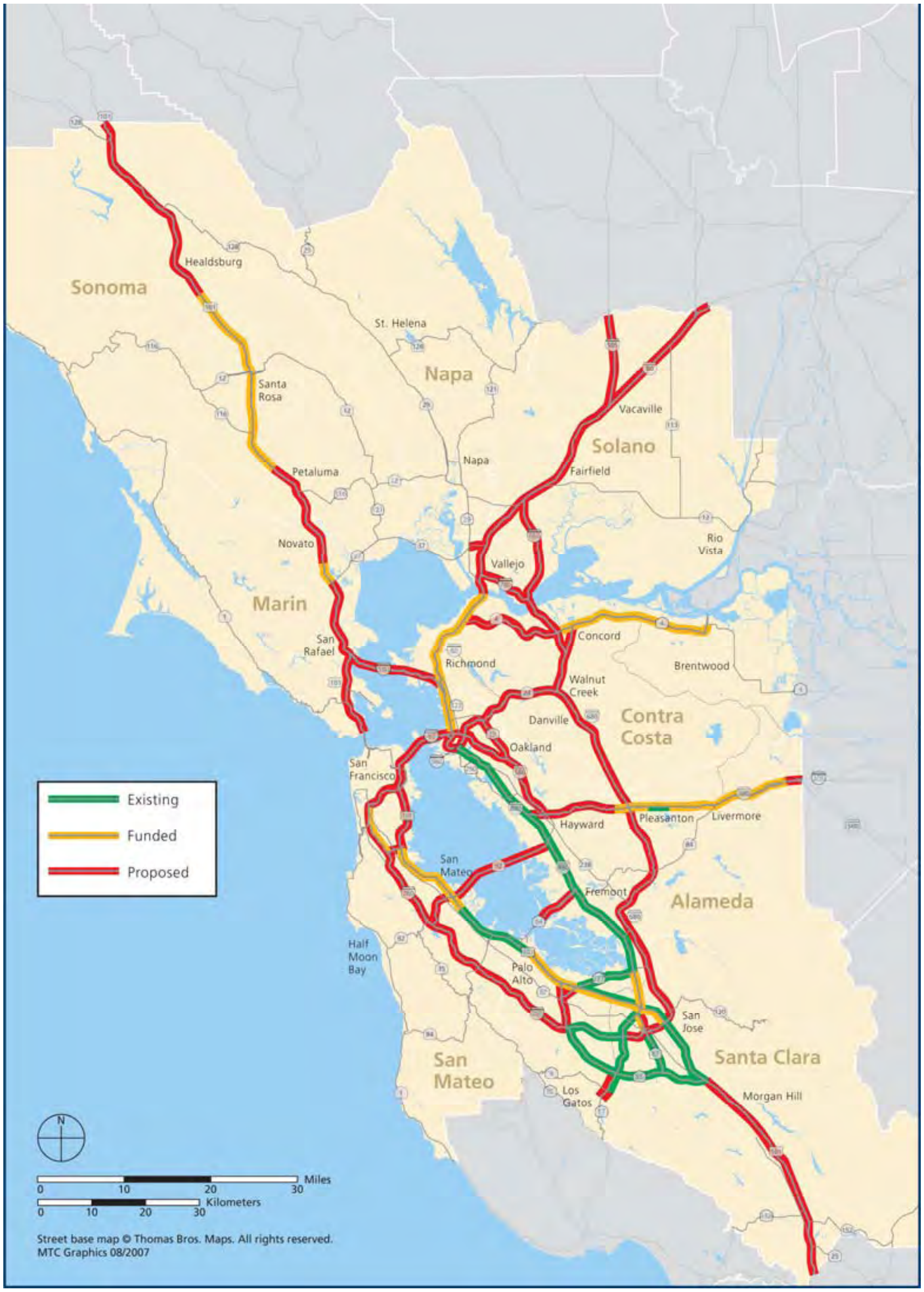

Figure A-2: Freeway Operations Package - Traffic Operations Systems

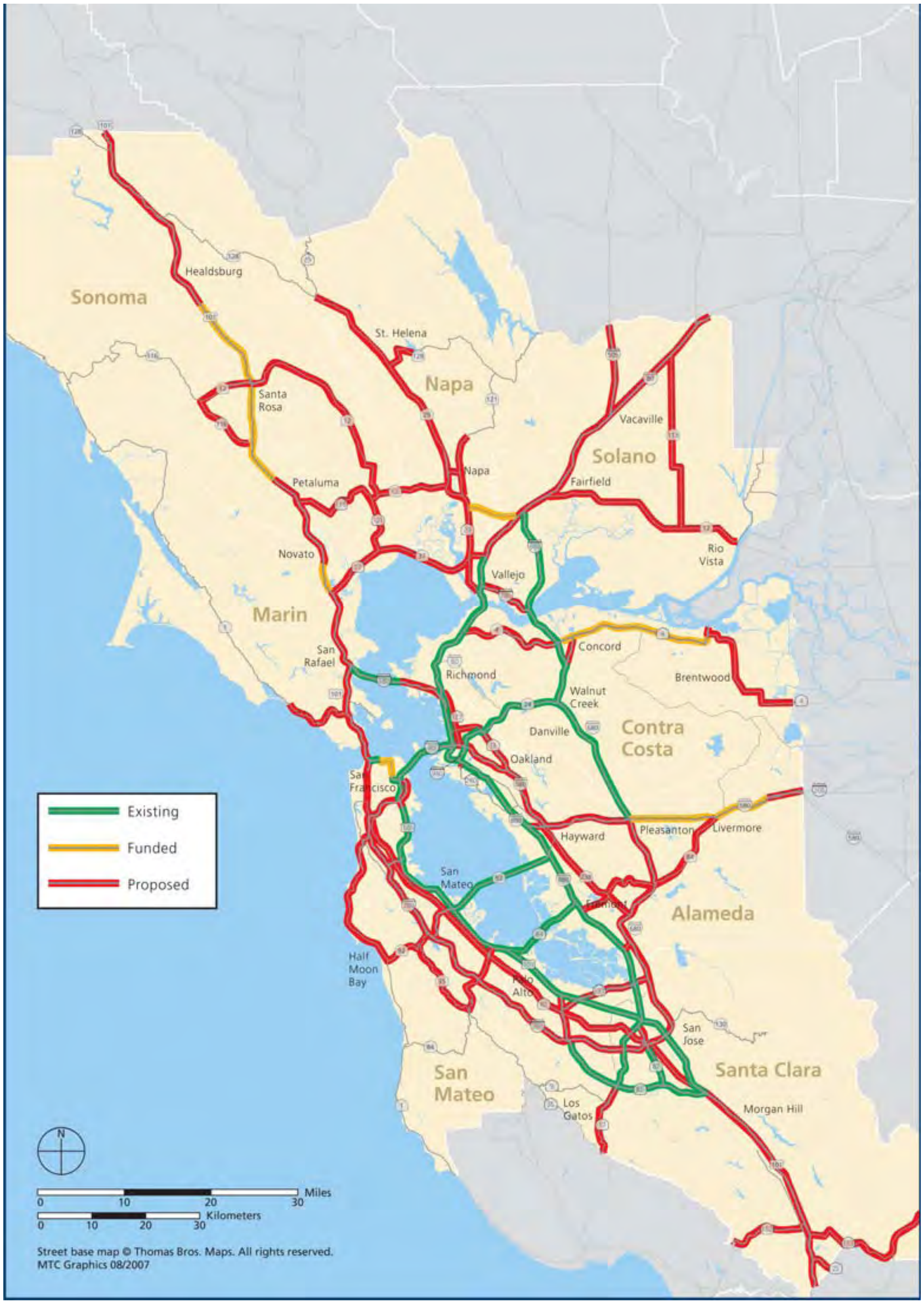

Figure A-3: Freeway Operations Package - HOV Lane Gap Closures

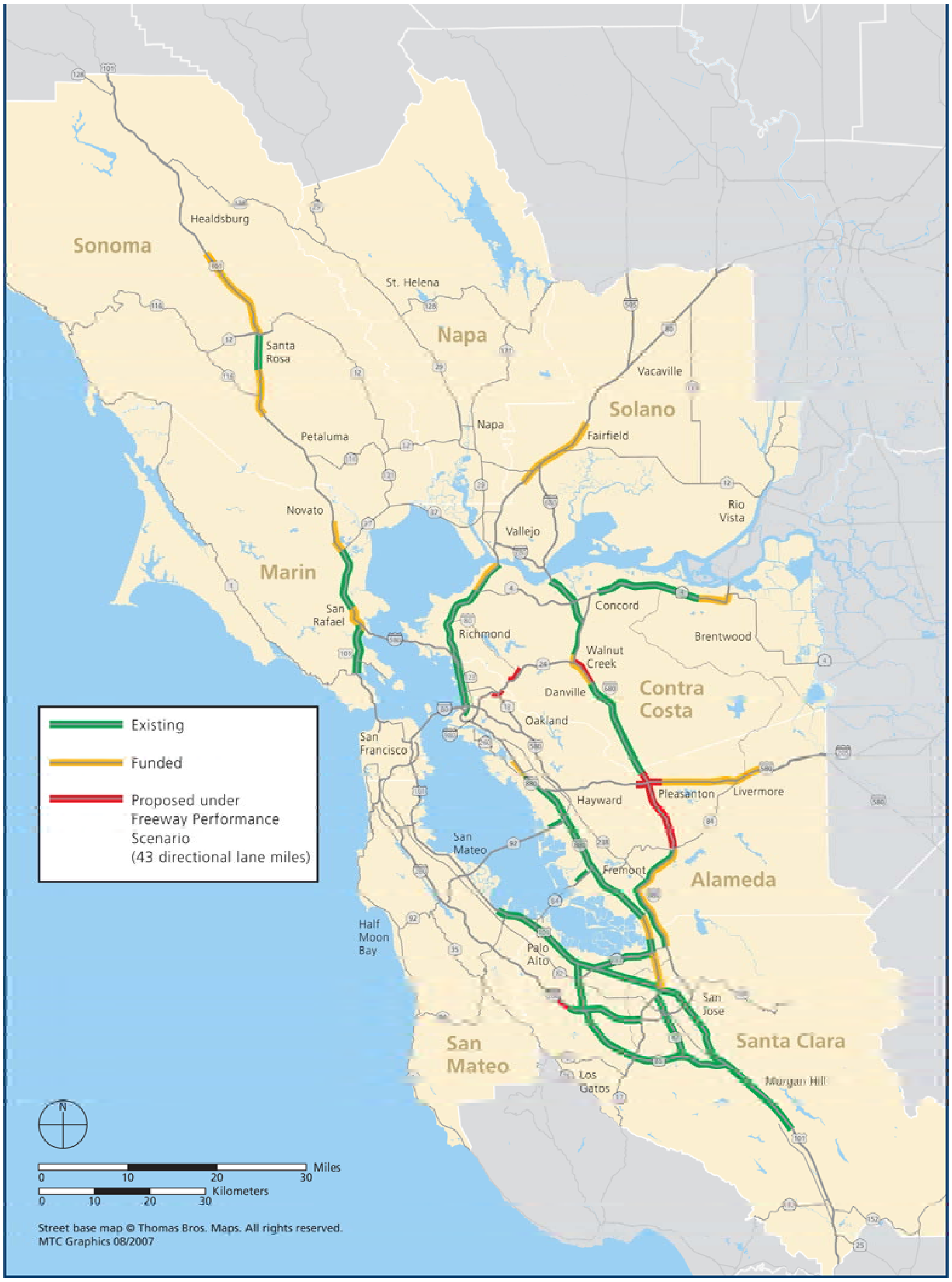

Figure A-4: HOT/Bus Investment Package - Regional HOT Network

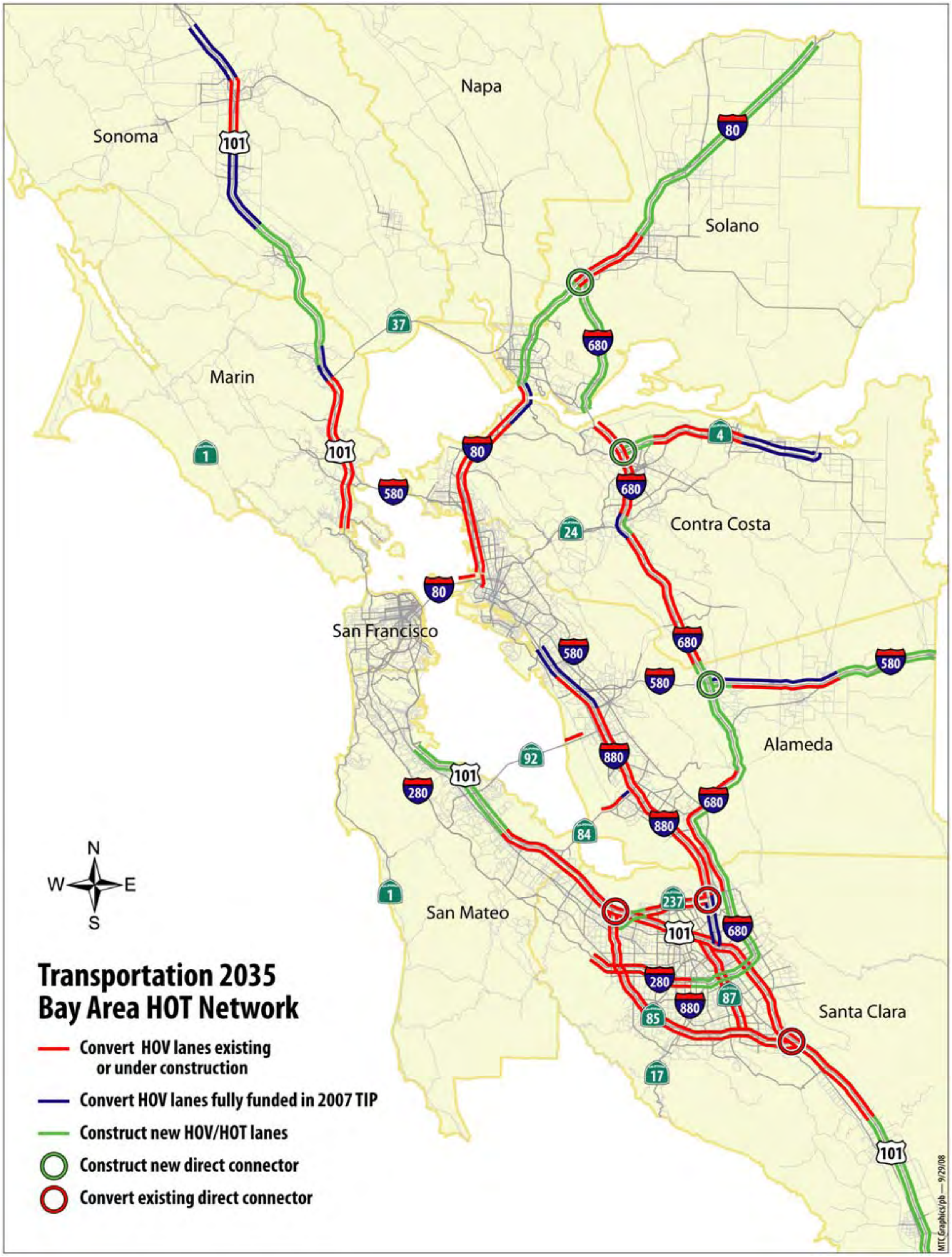

Figure A-5: Level of Service- AC Transit, MUNI, & VTA in the Base Case Scenario (2035 AM Peak)

LOS Benchmarks for Headways

LOS	Headway
A+	5 minutes or better
A	6 – 10 minutes
B	11 – 15 minutes
C	16 – 20 minutes
D	21 – 30 minutes
E	31 minutes and longer

Figure A-6: Level of Service: AC Transit, MUNI, & VTA in the HOT/Bus Package (AM Peak)

LOS Benchmarks for Headways

LOS	Headway
A+	5 minutes or better
A	6 – 10 minutes
B	11 – 15 minutes
C	16 – 20 minutes
D	21 – 30 minutes
E	31 minutes and longer

Figure A-7: The "Rapid" Corridors in the HOT/Bus Investment Package

Table A-1: "Rapid" Corridors with Proposed/Planned Rapid Bus and BRT Services in the HOT/Bus Investment Package

ID	County	Corridor	Key Representative Routes
1	Alameda County	Telegraph Ave, International Blvd	#1[4], #1R/BRT
2	Alameda County	Mission Blvd	#99, #99 Rapid (concept)
3	Alameda County	Hesperian Blvd	#97, #97 Rapid (concept)
4	Alameda County	San Pablo Ave	#72, #72M, #72R
5	Alameda County	MacArthur Blvd	#NL (concept upgrade to NR Rapid)
6	Alameda County	Dublin Blvd	#Dublin Rapid (concept)
7	Alameda County	Owens Dr, Santa Rita, Stanley Blvd, Railroad, East Ave	#10, #Livermore Rapid (planned)
8	Alameda County	University Ave, College Ave, Broadway, Santa Clara Ave	#51 (concept modified to Rapid)
9	Contra Costa County	San Ramon Valley Road	#121, #San Ramon Rapid (concept)
10	Contra Costa County	Pacheco Blvd, Contra Costa Blvd (Martinez-Walnut Creek)	#Martinez-WC Rapid (concept)
11	Contra Costa County	Treat Blvd	#115 (concept upgraded to Rapid)
12	Contra Costa County	Ygnacio Valley Road	#107, #Ygnacio Valley Rapid (concept)
13	Marin County	San Rafael-Sausalito	#22, #22X Rapid (concept)
14	Marin County	Fairfax-San Rafael	#23, #23X Rapid (concept)
15	San Francisco	Van Ness Ave	#47, #49
16	San Francisco	Geary Blvd	#38, #38L, #38XA, #38XB
17	San Mateo County	El Camino Real	#391, #El Camino Real Rapid (concept)
18	San Mateo County	Bayshore Blvd	#292, #Bayshore Rapid (concept)
19	Santa Clara County	El Camino Real	#22, #522 BRT (planned)
20	Santa Clara County	Stevens Creek Blvd	#23, #523 Rapid (concept)
21	Santa Clara County	Monterey Highway	#68, #568 Rapid (concept)
22	Santa Clara County	Sunnyvale-Cupertino	#54, #554 Rapid (concept)
23	Sonoma County (Santa Rosa)	Santa Rosa Ave Mendocino Ave	#1, #18, #20 Santa Rosa Rapid (concept)
24	Sonoma County (Santa Rosa)	College Ave Montgomery Drive	#2, #3, #21 College Ave Rapid (concept)

[4] In the Base Case, the now-defunct 40L, 82, and 82L were used as surrogates for the new 1 and 1R.

Table A-2: Regional Rail and Water Transit Investment Package - Regional Rail Improvements

The Regional Rail Plan recommends the following services and improvements for regional rail without high-speed rail. For purposes of this investment package, these regional rail improvements will be augmented as appropriate to accommodate high-speed rail over both Altamont Pass and Pacheco Pass.

BART – Reinvest in existing system to improve reliability and make the following improvements:

- Improve Core Capacity by making modifications to vehicles and stations as well as track and signals to accommodate passenger growth over the long term
- Implement connectivity improvements to connect BART with standard railroad services and regional bus lines in various corridors including a one-station extension to an intermodal with ACE at Isabel/Stanley
- Construct 4th track through Oakland to facilitate throughput and improve transfer convenience between East Bay and Transbay lines
- Develop Infill stations at various locations keyed to local land use opportunities in accordance with BART station planning policies
- Further define "Metro" service plan to increase capacity, coverage and reliability to inner Bay Area including the Oakland - Transbay – San Francisco zone
- Pursue construction of a second Bay Crossing with new subway line to improve coverage to San Francisco in the long term (paired with rail tunnel)

The Transbay Tube under San Francisco Bay is the backbone of the system, with a throughput of 24-27 trains in each direction during the peak hour. Baseline improvements would improve service reliability and increase capacity of transbay car fleet with operation on 120-second headways. The Regional Rail Plan includes the provision of a second tube and San Francisco subway to relieve the existing tube.

Regionally, BART currently operates five lines as follows:

- Pittsburg/Bay Point ↔ Daly City: Service is provided on weekdays every 15 minutes early mornings, during peak periods, midday and evenings. Service is provided every 20 minutes late evenings and all day Saturdays and Sundays.
- Richmond ↔ Daly City: Service is provided on weekdays every 15 minutes during peak periods and midday and on Saturdays every 20 minutes during peak periods and midday. No Sunday service.
- Dublin/Pleasanton ↔ Millbrae: Service is provided on weekdays every 15 minutes early mornings, during peak periods, midday and evenings. Service is provided every 20 minutes late evenings and all day Saturdays and Sundays.
- Fremont ↔ Daly City: Service is provided on weekdays every 15 minutes during peak periods and midday and on Saturdays every 20 minutes during peak periods and midday. No Sunday service.
- Fremont ↔ Richmond: Service is provided on weekdays every 15 minutes early mornings, during peak periods, midday and evenings. Service is provided every 20 minutes late evenings and all day Saturdays and Sundays.

The Baseline anticipates reductions in headways to provide 12-minute service on all regional lines. In the longer term, in conjunction with the Regional Rail Plan, BART is considering development of a "Metro" service plan which would further reduce headways in the inner core to as low as 3-5 minutes depending upon the number of routes present.

- **US 101 North** – Implement SMART project; service plan in the early years will have trains operating on 30-minute headways during peak periods with an approximate 90-minute schedule between Larkspur and Cloverdale. Make capacity and operational improvements over the long term to support 20-minute peak headways and higher ridership levels.

- **North Bay** – Preserve corridor in near term and develop north-south and east-west services using standard equipment in the long term with service frequencies on each route of approximately 60 minutes throughout the day with timed transfers at key locations.

- **I-80 & East Bay** – Expand the East Bay rail network from San Jose to Sacramento to 3 tracks with 4 track sections from Oakland to Richmond and in Solano County to support operation of standard higher speed railroad equipment compatible with freight traffic.

  Current Capitol Corridor schedules provide approximate 60-minute headways during peak periods and shoulders of peak periods with approximately 190-minute running time in the Sacramento – Oakland segment and variable headways (14 trains daily) with approximate 70-minute running time Oakland to San Jose. Baseline improvements will reduce headways Sacramento – Oakland segment to approximately 40 minutes with 90-minute headways Oakland – San Jose. Regional rail plan improvements will further reduce aggregate headways Sacramento – Oakland to as low as 15 minutes and will reduce travel time between Sacramento and San Jose to 149 minutes. Some of the service in the inner East Bay may be provided by shorter distance trains operating between Union City and Hercules.

- **Transbay** – Provide near term investments in BART Core Capacity including provision of higher-capacity cars, track and signaling and operational improvements; provide new transbay tube and San Francisco BART line paired with rail tunnel in long-term future.

  Currently, the maximum number of trains operating in the peak hour is 27 or 28. Baseline improvements will support reliable headways of 2 minutes in existing tube. The Regional Rail Plan includes a second tube and San Francisco line to distribute passengers and relieve overcrowding on the existing tube.

- **Peninsula** – Expand Caltrain to 3 or 4 tracks where feasible and operate with lightweight electric multiple-unit equipment to for rapid acceleration and frequent express and local service on the Peninsula.

  Current service plan includes a mix of locals, limited stop trains and "Baby Bullet" express trains with aggregate headways of approximately 15 minutes during peak periods and 30 minutes off peak. Locals operate on approximate 95-minute schedules and express trains on approximate 60-minute schedule. Baseline improvements to the service plan will add trains to reduce aggregate headways to 10 minutes peak period and 20 minutes off peak. The Regional Rail plan anticipates the operation of additional trains to resulting in 7-1/2 minute headways during peak periods and 15 minutes off peak.

- **South Counties** – Caltrain currently operates 6 daily trains to Gilroy. Baseline improvements will enable an operating plan with 2-hour headways in the peak period, peak direction of travel. The Regional Rail Plan includes extension of service to Salinas with further expansion of rail services in South Bay cities using standard equipment to provide rail connections to Monterey and Santa Cruz. Approximate hourly service would be provided on all lines with timed transfers at key locations.

- **Dumbarton** – The Baseline service includes approximately two trains per hour operating between Union City and the Peninsula. The Regional Rail Plan includes provision of separate passenger-only trackage to Union City to support operation of lightweight compatible with Peninsula train operations allowing Dumbarton trains to interline with Peninsula services. Peak period trains would operate at 30-minute headways between Union City and the Peninsula with hourly service throughout the day.

- **Tri Valley / I-680** – The existing ACE schedule includes 8 daily trains between Stockton and San Jose operating westbound in the am and eastbound in the pm. Trains operate on approximate 135 minute schedule. The Baseline improvements assumes the addition of trains resulting in 30 minute headways in peak travel direction only. Regional Rail plan would expand the Altamont and Tri Valley corridor lines to improve service reliability by adding trackage to the existing UPRR line and/or putting segments of the abandoned SPRR back in service to support expanded and improved passenger service along the ACE rail corridor and to accommodate regional freight trains; develop regional bus options in I-680 corridor. Hourly service would be provided in both directions with 30 minute service for peak period peak direction trains with an approximate 100-minute running time between Stockton and San Jose.

- **Central Valley** – Currently Caltrans Division of Rail operates 8 long haul trains daily between Oakland and Bakersfield with 4 long haul trains daily between Sacramento and Bakersfield. The Division of Rail is currently revising its long range plan. The Regional Rail plan includes expansion of regional service in the Central Valley to provide a regional corridor service between Sacramento and Merced over the long term, interlined with ACE services and complementing the San Joaquin long haul trains. Regional trains would operate on hourly schedules between Merced and Sacramento. Additional trains would operate from Modesto to Oakland or San Jose also on an hourly schedule resulting in 30-minute service over Altamont Pass between the San Joaquin Valley and the Bay Area.

High-Speed Rail – Altamont with Pacheco

- **Altamont with Pacheco** – With a higher investment in Bay Area segments, high-speed trackage could be developed in both the Altamont Pass and Pacheco Pass. Northern California regional services would be primarily routed over Altamont and statewide trains from the south would be routed over Pacheco. With this option, four track sections would not be required. This would result in reduced cost compared to development of both segments with four track sections and would substantially reduce the right-of-way requirements at tight spots as well as reduce some of the adjacency impacts where the alignment would run through developed areas (most notably through Tracy, Livermore, Pleasanton and Fremont along the Altamont alignment and thorough Gilroy, Morgan Hill and San Jose along the Pacheco alignment.) Operating plans could be developed to include some “limited stop” service between Sacramento and Bay Area cities via Altamont in conjunction with regional trains making all stops. Although this solution would be the highest cost, it would combine the travel time advantages of both routes and would retain the high level of service to all three Bay Area population center for statewide trains operating from the south

Table A-3: Regional Rail and Water Transit Investment Package - Ferry Service Improvements

Based on Water Transit Authority 2003 Implementation and Operations Plan

Operator	Route Name	Existing or New	End Points	One-way Trip Time (min)	Peak Headway (min)	Off-Peak Headway (min)
City of Alameda	"Alameda/Oakland-SF"	Existing	**Alameda/Oakland/San Francisco**	22	22	28
City of Alameda/Harbor Bay	"Harbor Bay-SF"	Existing	**Harbor Bay/San Francisco**	27	28	-
Baylink	"Vallejo-SF"	Existing	**Vallejo/San Francisco**	57	22	28
Golden Gate Ferry	"Sausalito-SF"	Existing	**Sausalito/San Francisco**	23	22	28
Golden Gate Ferry	"Larkspur-SF"	Existing	**Larkspur/San Francisco**	36	20	28
Blue and Gold Fleet*	"Sausalito-SF"	Existing	**Sausalito/San Francisco**	20	-	28
Blue and Gold Fleet*	"Tiburon-SF"	Existing	**Tiburon/San Francisco**	21	22	28
Water Transit Authority	"Antioch/Martinez-SF"	New	**Antioch/Pittsburg/Martinez/SF**	95	28	40
Water Transit Authority	"Berkeley-SF"	New	**Berkeley / San Francisco**	28	22	32
Water Transit Authority	"Hercules-SF"	New	**Hercules/ San Francisco**	41	28	40
Water Transit Authority	"Oakland to South SF"	New	**South San Francisco / Oakland**	32	24	30
Water Transit Authority	"Oakland to South SF"	New	**Harbor Bay/South San Francisco**	37	28	-
Water Transit Authority	"Richmond-SF"	New	**Richmond/San Francisco**	33	24	32
Water Transit Authority	"Redwood City-SF"	New	**Redwood City/San Francisco**	51	28	28
Water Transit Authority	"Redwood City-SF"	New	**Harbor Bay/Redwood City**	60	28	-
Water Transit Authority	"Treasure Island-SF"	New	**Berkeley/Treasure Island**	23	28	-
Water Transit Authority	"Treasure Island-SF"	New	**Oakland/Treasure Island**	23	28	-
Water Transit Authority	"Treasure Island-SF"	New	**Treasure Island/San Francisco**	16	20	24
Water Transit Authority	Further Study	Further Study	**Martinez/San Francisco**	57	28	40
Water Transit Authority	Further Study	Further Study	**Port Sonoma/San Francisco**	59	30	34
Water Transit Authority	Further Study	Further Study	**Moffett Field/ San Francisco**	58	30	-

2. Cost of Investment Packages

Tables A-4 through A-6 show the total capital cost and net annual operating and maintenance cost assumptions for the major components for each of the three infrastructure investment packages.

Table A-4: Freeway Operations Investment Package Cost Summary (millions of 2007$)

	Total Capital Cost	Net Annual O&M Cost
TOS and ramp metering	$553	$16
HOV gap closures [1]	$ 60	-
Arterial signal coordination [2]	-	$ 9
Total	**$ 613**	**$24**

[1] The Freeway Operations investment package adds 43 HOV lane miles at $1.4 million per lane mile. Cost assumes use of existing shoulders.
[2] Signal coordination assumes $2,000 to retime each signal. Each signal need to be retimed every 4 years. Retiming costs $500 per signal per year. There are 17,054 signals in the Bay Area.

Table A-5: HOT/Bus Investment Package Cost Summary (millions of 2007$)

	Total Capital Cost	Net Annual O&M Cost
HOT Lanes: Conversion of existing carpool lanes [1]	$ 564	-
HOT Lanes: Freeway widening and HOT equipment [2]	$ 2,557	-
Local Buses and Light Rail [3]	$ 1,186	$ 539
Local Transit Priority Measures; Rapid Bus/BRT facilities [4]	$ 1,721	-
Express Buses [5]	$434	$77
Express Ramps, transit centers and Park and Ride [6]	$ 1,545	-
Total	**$8,007**	**$616**

[1] Annual HOT network net O&M cost (approx $100 million in 2035) not shown since revenues fully fund O&M costs. Costs based on Bay Area HOT Network Study (December 2008).
[2] Assumes 290 miles of freeway widened for HOV/HOT lanes. Costs based on Bay Area HOT Network Study (December 2008).
[3] Includes vehicles; costs for new or expanded transit yards are not included. Does not include guideway costs. Net Annual O&M costs assume a 35% farebox recovery.
[4] 410 route-miles of unfunded corridors identified; cost factors range from $2M to $16M per route-mile depending on degree of transit priority (source: AC Transit)
[5] Net Annual O&M costs assume a 35% farebox recovery. Estimated by Cambridge Systematics Inc. (October 2007)
[6] Estimated by Cambridge Systematics Inc. (October 2007)

Table A-6: Rail and Ferry Investment Package Cost Summary (millions of 2007$)

	Total Capital Cost	Net Annual O&M Cost
Regional Rail Plan [1]	$ 49,584	$ 934
High speed rail [2]	$ 14,200	-
Ferry (vessels and terminal) [3]	$438	$ 276
Total	**$ 64,222**	**$1,210**

[1] Capital costs include $35 billion from the Regional Rail Plan for the San Francisco Bay Area (September 2007) and $13.3 billion from MTC Resolution 3434. Consistent with Regional Rail Plan, estimate does not include vehicle costs, which would be addressed statewide. Net Annual O&M costs assume a 35% farebox recovery.
[2] Capital costs are for Pacheo and Altamont minus Caltrain and Dumbarton rail costs. Consistent with Regional Rail Plan, estimate does not include vehicle costs or O&M costs for this element.
[3] Costs from the Water Transit Authority (WTA) Implementation and Operations Plan (IOP) (July 2003) includes terminal and vehicle costs.

3. Summary of Methodology and Assumptions Updated for Revised Vision Analysis

MTC staff first undertook the Vision ("What If") Analysis in fall 2007. The results of this original analysis were presented at the October 2007 Transportation 2035 Forum and published in the report Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Vision 2035 Analysis Data Summary", November 2007.

In preparing analysis for the Draft Transportation 2035 Plan and Environmental Impact Report, staff updated a number of travel forecasting methodologies and assumptions. MTC staff then revised the Vision ("What If") Analysis to reflect the updated assumptions and methodologies. This section briefly summarizes several updated assumptions and methodologies, highlighting major differences from the analysis conducted in the fall of 2007. For full documentation of the travel demand modeling undertaken for the Draft Transportation 2035 Plan and Environmental Impact Report, see "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary" (December 2008).

Table A-7, at the end of this section, shows the original and revised Vision forecasting results.

General

- MTC staff re-validated the travel demand model with a focus on re-calibrating the auto ownership model to match data from the 2006 American Community Survey. This yielded fewer zero-vehicle households and higher vehicles per household rates. Daily transit ridership and daily traffic were also re-validated.

Gasoline Prices and Fuel Economy

- The fall 2008 analysis assumes higher fuel costs in 2035. Staff made this adjustment in response to upswing in fuel prices in spring and summer 2008. The fall 2007 analysis assumed year 2035 gasoline prices of approximately $4.00/gallon (in 2008$). When gasoline prices in summer 2008 reached over $4.00/gallon, staff felt is appropriate to increase the year 2035 gas price assumption to approximately $7.50/gallon (2008$).

- The fall 2008 analysis reflects average fuel economy associated with Pavley Phase I (near-term) and Phase II (mid-range) technology requirements. The fall 2007 analysis reflected average fuel economy associated with Pavley Phase I requirements only; these result in lower average miles per gallon. Emissions factors reflecting the Phase II requirements were made available by the California Air Resources Board in early 2008, in time for the fall 2008 analysis, but not the original fall 2007 analysis.

- The increase in fuel economy partially offsets the higher assumed prices of fuel. Ultimately, however, the average fuel cost per mile in year 2035 is higher in the revised Vision analysis (fall 2008) than in the original fall 2007 analysis as shown below.

Year 2035 Fuel Cost per Mile in Fall 2007 (Original) and Fall 2008 (Revised) Vision Analyses (2008$)

	Fall 2007 (Original Analysis)	Fall 2008 (Revised Analysis)
Fuel cost per gallon	$3.83	$7.47
Average fuel economy in miles per gallon (mpg)	28.0 mpg	32.2 mpg
Fuel cost per mile	14.2 cents per mile	23.2 cents per mile

Importantly, staff made several methodology updates (described briefly below) that cause the impact of the increase in fuel cost per mile not to be immediately apparent when comparing analysis results for the original fall 2007 and revised fall 2008 analyses. For example, one would expect VMT, delay and emissions rates to fall with the increased cost in driving; however, these other updates are such that this is not always the case.

Particulate Emissions Factors

- Based on updated information from the Bay Area Air Quality Management District, MTC staff applied lower particulate emissions factors for entrained road dust in the fall 2008 revised analysis than in the fall 2007 original analysis. This has the overall effect of decreasing year 2035 particulate emissions forecasts.

Particulate Matter Emissions Factors: Entrained Road Dust

	Fall 2007 (Original Analysis)	Fall 2008 (Revised Analysis)
$PM_{2.5}$ emissions factor	0.076 grams/mile summertime	0.060 grams/mile annual average
PM_{10} emissions factor	0.342 grams/mile wintertime	0.320 grams/mile wintertime

External Trips

- At the time of the fall 2007 analysis, staff had not had an opportunity to update forecasts of future year trips between the Bay Area and neighboring regions. As a result, that analysis assumed no growth in such trips from 2006 to 2035. For the fall 2008 analysis, staff was able to prepare external trip forecasts, which project some growth. This has the overall impact of increasing forecasts of year 2035 vehicle miles traveled per person.

External Trips: Daily Volumes at External Gateways

	Fall 2007 (Original Analysis)	Fall 2008 (Revised Analysis)
Year 2006	595,700	595,700
Year 2035	595,700	796,600
Projected Growth	0%	34%

Daily Delay Calculations

- Prior to fall 2008, MTC estimated daily delay by factoring up forecasts of AM peak period delay. For the Transportation 2035 Draft Plan, MTC staff applied an updated "time-of-day" forecasting methodology, which better estimates congested travel speeds and delay for five time periods during the day. Compared to prior forecasts, the result is a "flattening the peak periods" and increased congestion forecast in midday and evening periods, with higher total daily delay forecasts for year 2035.

- Traffic assignment convergence criteria were tightened. This essentially means the model ran more iterations before reaching the equilibrium traffic assignment which is used as the basis for traffic-related metrics including delay and vehicle miles traveled. This tend to reduce by about three percent peak period vehicle hours of delay.

Housing Expenditures

for the Affordability Objective, which measures the share of household income spent on housing and transportation

- The fall 2008 revised analysis uses information from the 2006 American Community Survey to estimate current expenditures on housing. As a result, the estimated share of income spend on housing and transportation is lower in the fall 2008 revised analysis than in the fall 2007 original analysis. Because housing costs are held constant, this updated also affects the value of the year 2035 objective, which is set to 10 percent below the 2006 level, and the year 2035 forecasts.

Percent of Household Income Spent on Housing and Transportation
For Low and Moderate Low Income Groups

	Fall 2007 (Original Analysis)	Fall 2008 (Revised Analysis)
2006 Housing expenditure	45%	39%
2006 Transportation expenditure	22%	22%
2006 Combined expenditure	67%	61%
2035 Objective (10% decrease from 2006 in combined expenditure)	61%	55%

However, the assumed increase in the fuel costs in 2035 (see above), means the share of income spent on housing and transportation combined is higher in the revised analysis, as shown in Table A-7.

Land Use Sensitivity Test

- Staff made no changes to the basic land use assumptions applied in the fall 2007 original analysis. However, in presenting the impact of the Land Use Test on the affordability objective in fall 2007, staff assumed a direct subsidy to low-income and moderate-low income households in near transit so that they spent no more than 30 percent of their income on housing. The effect of this subsidy was to lower projected average housing expenditures for all low- and moderate low-income households to 39 percent of income. As a result, the projected, combined expenditure on housing and transportation by low- and moderate low-income households fell below the objective of 60 percent. In the fall 2008 revised analysis, staff did not assume this direct subsidy and the projected, combined expenditure on housing and transportation failed to achieve the performance objective.

Pricing Sensitivity Test

- As a result of the higher assumed baseline gas prices in the fall 2008 revised analysis, MTC staff revised the Pricing Test assumptions to reflect a less pronounced incremental price increase.
  The Pricing Test has three components:
  1. Tax on carbon or vehicle miles traveled (VMT)
  2. Congestion pricing fee applied to congested freeways
  3. Parking fee increase

  For congestion pricing and parking fess, MTC staff used identical assumptions in the original fall 2007 and revised fall 2008 analysis. However, staff did revise the carbon/VMT tax assumptions. In the original fall 2007 analysis, the pricing test reflected an increase in fuel prices from $3.83 to $7.67 per gallon and a doubling of non-gas prices, resulting in an increase in the average cost per mile from 23 to 46 cents to reflect increase in. In the revised fall 2008 analysis, staff assumed an increase in fuel prices from $7.47 to $9.07 per gallon and a 5 cent per mile increase in non-gas prices, resulting in an increase in the average cost per mile from 23 to 28 cents. Note that, despite the fact gas price per gallon is higher in the revised analysis, the cost per mile is lower; this reflects the assumed improvements in fuel economy associated with Pavley Phase 2 (see discussion above).

  The table below summarizes the pricing test assumptions and resulting cost for a typical 22-mile round trip daily commute in year 2035.

Pricing Test Assumptions and Impact on Typical Commute (22 miles round trip)

	Fall 2007 Vision		Transportation 2035 (Fall 2008)	
(all costs in 2008$)	**2035 Base**	**2035 Pricing**	**2035 Base**	**2035 Pricing**
Assumptions				
Gas price	$3.83	$7.67	$7.47	$9.07
Fuel economy	28.0	28.0	32.2	32.2
Gas price/mile	$0.14	$0.28	$0.23	$0.28
Non-gas price/mile	$0.09	$0.18	$0.16	$0.19
Total auto operating cost/mile	$0.23	$0.46	$0.39	$0.47
Congestion pricing	none	$0.25 per mile for fwys with V/C > 0.9	none	$0.25 per mile for fwys with V/C > 0.9
Parking Costs ($1/hour surcharge - all trips)	$97 to $524/ month	$105 to $524/ month	$97 to $524/ month	$105 to $524/ month
Impact on Typical 22-mile Round Trip Commute in 2035				
Auto operating cost	$5.06	$10.12	$8.58	$10.34
Congestion charge (assumes full trip on congested freeways)	$0.00	$5.50	$0.00	$5.50
Parking	$0 to $23.80	$12.41 to $32.80	$0 to $23.80	$12.41 to $32.80
Total	$5.06 to $28.86	$28.03 to $47.42	$8.58 to $32.38	$28.25 to $47.64
Increase (using low end cost)		5.6		3.3

Table A-7: Comparison of Fall 2007 and Fall 2008 Vision (“What If”) Analysis Results

	Year 2006	Year 2035 Target	Year 2035 No Build	Year 2035 Best Investment	Year 2035 Investment + Pricing + Land Use
VHD/Capita (annual); best investment = Freeway Operations					
Fall 2007 Vision	27	21	66	40	18
Fall 2008 Revised Vision	39	31	72	43	31
VMT/Capita (daily); best investment = HOT/Bus					
Fall 2007 Vision	19.0	17.1	19.7	19.4	17.7
Fall 2008 Revised Vision	20.3	18.2	21.3	21.0	19.3
CO2 (thousands of tons/day); best investment = HOT/Bus					
Fall 2007 Vision	87	50	95	92	82
Fall 2008 Revised Vision	90	50	77	74	66
PM2.5 (tons/day); best investment = HOT/Bus					
Fall 2007 Vision	20	18	26	26	23
Fall 2008 Revised Vision	17	16	21	20	19
PM10 (tons/day); best investment = HOT/Bus					
Fall 2007 Vision	69	38	96	94	86
Fall 2008 Revised Vision	66	36	85	83	77

Affordability (percent of income spent on housing and transportation combined, for low and moderately-low income households)

	Year 2006	Year 2035 Target	Year 2035 No Build	Year 2035 Land Use*	Year 2035 Pricing + Land Use*
Fall 2007 Vision	67%	61%	63%	57%	71%
Fall 2008 Revised Vision	61%	55%	59%	58%	61%

* Fall 2007 Vision assumed direct subsidy to low- and moderate low-income households living in transit oriented developments. Fall 2008 Revised Vision assumed no direct subsidy

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Transportation 2035 Plan
Performance Assessment Report
December 2008

Appendix B: Project Performance Assessment - Technical Background

Table of Contents

1. Projects Subject To Analysis

By Commission Policy, "committed" projects and programs as defined by the Planning Committee on January 11, 2008 (including Resolution 3434 transit expansion projects) are not subject to the project performance assessment.[1] However, as described in Section IV of the main report, staff later did review all committed projects with respect to the qualitative project assessment criteria.

All remaining projects, approximately 700 potential "discretionary" investments submitted in response to the December 2007 Call for Projects, are subject to the qualitative policy assessment. In addition,

Practical limitations preclude quantitative assessment of all 700 potential discretionary investments. However, it is informative to evaluate the highest-cost projects. Though typically small in number, projects with cost above $50 million typically account for 70 to 80 percent of discretionary investment decisions in the long-range plan. Thus, MTC staff used the additional guidelines below to select projects for the quantitative assessment:

1. Approximately 60 transit and roadway projects are included in the analysis based on a combination of cost and functional criteria: projects with total cost of $50 million (2007$) or greater and with area-wide impacts. Examples include:
   - New/enhanced transit service, including transit priority measures
   - Freeway-to-freeway interchanges
   - Freeway widenings, including HOV lanes & slow-vehicle lanes
   - State highway widenings and major arterial connectors/reliever route improvements

   A few projects that cost less than $50 million are included if they would have area-wide impacts. Examples include some freeway-to-freeway connectors and transit priority measures. Additionally, in a few cases, multiple project phases submitted as individual projects are grouped together for evaluation, even though individual phases cost less than $50 million. Examples include multi-phase interchange improvements.

   Transit expansion projects are included in the performance analysis only if the projects are well defined and the operators indicate a reasonable expectation of operating funding, a requirement for inclusion in the Transportation 2035 Plan, which must be financially constrained.

   HOT lane corridors submitted by Alameda and Santa Clara counties are bundled and evaluated as packages rather than as individual corridors. The regional HOT network is similarly evaluated as a package.

2. Due to technology and resource limitations, some transit and roadway improvements costing more than $50 million were not evaluated. These include projects considered to have localized impacts and other projects ill-suited for our analysis tools. Examples include:
   - Arterial or intersection improvements, except as noted above

[1] See MTC Resolution No. 3868 for a definition of committed projects.

- Auxiliary lanes, except in the Freeway Performance Initiative corridor studies
- Local interchanges
- Individual, new transit stations/stops for existing services
- Transit center improvements & parking expansion
- Core transit capacity improvements, which do not result in more frequent service, though they may impact carrying capacity
- Grade separations

3. The analysis also includes those regional programs not considered “Committed” by Commission policy. These are:
    - Transportation for Livable Communities (TLC)
    - Regional Bicycle Network
    - Lifeline Transportation Program
    - Local Streets and Roads Maintenance Shortfall
    - Transit Capital Shortfall
    - Climate Protection Campaign (new proposal for Transportation 2035)
    - Port Emissions/Clean Air Program (new proposal for Transportation 2035)
    - Means-Based Transit Discount Program (new proposal for Transportation 2035)

2. Quantitative Assessment: Modeling Approach and Approach to Costs

The regional travel demand model is used to estimate benefits for most of the projects in the quantitative assessment. See Part 4 of this appendix for methods used to evaluate the regional programs (e.g., Transportation for Livable Communities, the Regional Bicycle Network, Climate Protection Campaign, Local Roadway Maintenance and Transit Capital Shortfalls) that are not easily represented in the travel demand model.

About the Models Used in This Analysis

The primary tool to estimate project benefits is the travel demand model. Forecasting for the project assessment was conducted in spring 2008.[2] The current set of MTC travel demand models are typical of advanced trip-based travel models in use in the United States. MTC staff estimated these models in the mid-1990s using data from the 1990 Bay Area household travel survey (BATS1990).

The current trip-based models are a blend of disaggregate and aggregate demand models, all applied at an aggregate, zonal level with extensive market segmentation. Auto ownership models are nested logit choice in form, and include transit/highway accessibility variables. Trip generation models are either disaggregate household, worker or student trip production or aggregate zonal trip production/attraction in form, using hybrid cross-classification / multiple regression forms. Trip distribution models are standard gravity model formulations. Mode choice models are nested logit choice. Non-motorized trips (separate modes for bicycle and walk) are included in all mode choice models. Departure time choice for work trips is a binomial logit choice, whereas departure time choice for non-work trips is based on traditional trip peaking factors. Trip assignment procedures focus on daily traffic and transit trips, and A.M. peak period traffic volumes and speeds. Customized speed-flow delay curves are used in traffic assignment, including an Akçelik formulation for representing arterial speeds. The model system methodology incorporates full feedback from trip assignment back through auto ownership. Trip assignment (district-to-district travel times and costs) are also used as input to the land use allocation models used by MTC's sister agency, the Association of Bay Area Governments (ABAG). Detailed travel model specifications for this "BAYCAST-90" model system are available online at http://www.mtc.ca.gov/maps_and_data/datamart/forecast/.

Future MTC plans are to migrate to a fully disaggregate, activity-based model by 2009. Detailed information on these activities and plans are included on the MTC web site, here: http://www.mtc.ca.gov/maps_and_data/datamart/abm/

The current MTC model system incorporates 1,454 regional travel analysis zones in a region of 7,149 square miles.

[2] As a result, forecasts for the project assessment were conducted prior to the methodology and assumption updates documented in Section 3 of Appendix A and "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary" (December 2008).

MTC used the California Air Resources Board (CARB) model "EMFAC2007" for this study. This entailed creating a "lookup" table for pollutants of interest (grams per vehicle-mile for carbon dioxide, particulates), by the AM peak period volume-to-capacity ratio, and applying these pollutant factors at the individual link-level.[3]

MTC used the IDAS (ITS Deployment Analysis System) for producing estimates of non-recurring freeway delay. As with emissions, MTC developed a "lookup" table based on AM peak period freeway speeds to generate estimates of non-recurring freeway delay at the link level.

MTC used the Association of Bay Area Government's (ABAG) *Projections 2007* socio-economic forecasts for the year 2035 for this study. ABAG's *Projections 2007* was adopted by the ABAG policy board in Fall 2006, and published in December 2006. MTC staff then re-allocated ABAG's tract-level (1,405 total tracts) projections to MTC regional travel analysis zone level (1,454 total travel analysis zones).

The ABAG *Projections 2007* is not strictly a "trends-based" forecast, but is based on detailed analysis of land use policies and potentials for smart growth. From the ABAG documentation: "In this forecast, policy-based development potential is used for the years 2015-2035 in a manner which is broadly consistent with existing [general] plans, but also assumes a more 'Smart-Growth' based projection."

Method to Estimate Project-Level Benefits

Project benefits are measured as the differences in delay, emissions, driving, and/or personal expenditures between a "Build" scenario, which includes the project, and a "No Build" scenario, which represents conditions if the project is not built. All benefits are measured as annual differences in year 2035.

Projects were coded in year 2035 "Build" scenarios with two to five projects selected in any single scenario to avoid overlap of transportation impacts. Specifically, project serving overlapping travel markets were coded in different scenarios. With the exception of the HOT lane scenarios, transit and roadway projects were evaluated in separate scenarios. In several cases, multi-phase projects were grouped and evaluated as a single project. For example, improvements to multiple legs of particular interchange may have been submitted as separate

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[3] At this time this analysis was conducted, the California Air Resources Board could provide information for partial implementation only of the fuel economy standards called for in Pavley bill (AB 1493, 2002). Specifically, this analysis reflects fuel economy standards consistent with Phase I. This assumes that 75 percent of the overall Bay Area passenger fleet is consistent with either the short-term technology or mid-range technology included in AB 1493 and yields an average fuel economy of approximately 28 miles per gallon. If the analysis were conducted with the assumptions used in the performance assessment of the Vision ("What If") and Draft Transportation 2035 Plan, which assume Phase II with an average fuel economy of approximately 32 miles per gallon, the year 2035 emissions reductions attributable to all projects would likely be lower. For discussion of the latest fuel economy assumptions, see "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Data Summary" (December 2008).

projects and were evaluated as a single investment.[4] The 2007 Transportation Improvement Program was used as the "No Build" scenario; however, for several projects MTC staff adjusted the No Build so the analysis would better highlight the sometimes small changes between the No Build and Build conditions.

For roadway scenarios, MTC staff generated 2-hour AM peak period forecasts. For selected projects deemed to serve directional PM peak period trips (for example eastbound truck climbing lane on I-580), MTC staff also generated 2-hour PM peak period analysis; in such cases, the forecast showing the higher benefits was used. Staff reviewed the forecast results to define the projects' areas of influence, and then extracted the benefits (changes in VMT, delay, emissions and collisions) on the roadway network within those areas. Defining the areas of influence was an iterative process, involving some trail and error, to capture the key impacts while excluding model noise.

For transit projects, MTC staff generated daily forecasts. Areas of influence for transit projects were defined based on origin-destination pairs. Changes in zone-to-zone VMT, delay, emissions and collisions were aggregated to MTC's 34-superdistrict system and the resulting superdistrict origin-destination interchanges were allocated to each project.

Costs

The benefit cost measure is based on annualized total cost, which reflects capital costs divided by the expected life of the capital investment plus one year of net operating and maintenance costs. The total project cost, as opposed to the discretionary funding request, was used as the basis for the benefit-cost calculation. Project sponsors provided capital cost estimates. Where annual operating and maintenance cost estimates were provided, they were used. Where sponsors did not provide estimates (all cases were roadway projects), MTC staff estimated them. Both benefits and costs are expressed in 2007 dollars.[5]

[4] In such cases the tables showing results will list multiple RTP Identification (ID) numbers.
[5] Escalating to 2035 dollars would yield higher benefits and costs, but the same B/C ratio, since both benefits and costs would be escalated equally.

3. Valuations and Assumptions for Benefit Cost Measure

Valuations

The following values are used for monetizing the benefits. The values are in 2007 dollars. Wherever possible, valuations are consistent with those in the Cal B/C model, Caltrans' tool to estimate the value of investments. The Cal B/C model was used to analyze projects proposed for the Corridor Mobility Improvement Account Program from the State Infrastructure Bond in 2006.

- Value of time for recurrent congestion and transit travel time
  - Automobiles and in-vehicle transit travel times: $13.45 per hour (or $19.10 per vehicle, assuming average vehicle occupancy of 1.42). This is one-half of the mean hourly wage reported in the March 2006 San Francisco–Oakland–San Jose, California, National Compensation Survey (Bulletin 3135–33), published by the U.S. Department of Labor in January 2007. This methodology is also consistent with guidance from the US Department of Transportation.
  - Trucks**:** $31.26 per hour. This is equal to the transportation and utilities hourly wage reported in the 2001 Bureau of Labor Statistics (BLS) Covered Wages Program for California. To this, the value of fringe benefits and other employer costs and the value of cargo (conservatively estimated at $1.78, which corresponds to the value used in the Federal Highway Administration's HERS model) are added.
  - Out-of-vehicle transit travel time: $29.59 per hour (2.2 times the in-vehicle travel time)
- Value of time for nonrecurring congestion. Nonrecurring congestion is valued at three times the value of time for recurrent congestion. The value is based on Harry Cohen and Frank Southworth's article in the Journal of Transportation and Statistics, "On the Measurement and Valuation of Travel Time Variability Due to Incidents on Freeways," December 1999.
  - Automobiles: $57.30 per vehicle
  - Trucks: $93.78 per hour
- Accident costs. Accident values come from the 2005 Collision Data on State Highways report, which is the latest Caltrans summary of collision data from TASAS and is based on a Caltrans literature review conducted in the late 1990s. The method used for estimating these values is the comprehensive, or willingness to pay, method. The safety values include direct costs (out-of-pocket costs such as crash clean-up, injury treatment, property repair and replacement, workplace disruptions, and insurance claims processing) as well as human capital (lost work time) and the amount people are willing to pay to avoid injury.
  - Fatal collision: $4,305,200 per fatal collision
  - Injury collision: $64,200 per injury collision

- Average fatal and injury: $133,737 per collision (assumes 1.6% collisions are fatal of the fatal + injury total, from Caltrans' 2005 Collision Data on California State Highways - District 4)

- Emissions costs. The costs of particulate emissions measure the estimated health impacts of vehicle emissions on people. The values are derived from epidemiological studies measuring the increase in health problems (such as headaches, chronic respiratory problems, or mortality) as a function of dose response and population. Revealed and expressed preference surveys help place a monetary value on these health effects. Recent and extensive cost estimates are available from a study by Donald McCubbin and Mark Delucchi (McCubbin, D. and M. Delucchi. "The Social Cost of the Health Effects of Motor Vehicle Air Pollution." Report #11 in the Series, The Annualized Social Cost of Motor-Vehicle Use in the United States, based on 1990-1991 Data, Institute of Transportation Studies, University of California, Davis, August 1996.) For this analysis, the Bay Area Air Quality Management District reviewed the McCubbin and Delucchi analysis and suggested refined estimates based on Bay Area-specific conditions.

  - $PM_{2.5}$: $350,000 per ton
  - PM_{10}: $21,216 per ton

  The value of carbon dioxide emissions is based on guidance issued in December 2007 by the United Kingdom Department for Environment, Food and Rural Affairs. The valuation reflects the full global cost of an incremental unit of CO2 emissions from the time of production to the damage it imposes over the whole of its time in the atmosphere. The recommended methodology builds on the Stern Review (2006), which is widely recognized as an authoritative assessment of the global costs and impacts of greenhouse gas emissions. For a full description of the methodology see:
  http://www.defra.gov.uk/environment/climatechange/research/carboncost/

  - CO_2: $70 per ton in 2035

- Vehicle Operating Costs: $0.23 per VMT

Other Parameters

- Conversion factors for peak period results to daily
  - Vehicle miles traveled, emissions and accidents: 6.7
  - Vehicle hours of travel: 6.2
  - Vehicle hours of delay and transit travel time: 5.1
- Conversion of number for daily results to annual: 352.7

Operating and Maintenance (O&M) Costs

For transit projects, project sponsors provided O&M costs. If not provided, net O&M costs, after fare revenue, are estimated based on average operator farebox recovery rate computed from data in the 2007 Statistical Summary Report or, for express bus services, an average farebox recovery rate of 35% is assumed.

Project sponsors did not generally provide O&M cost estimates for roadway projects. For these projects, MTC staff estimate lane miles added and apply unit annual O&M costs:

- Freeway: $93,700 per lane mile – From Caltrans Headquarters Maintenance Division
- Local Roadway (major arterials): $40,353 per lane mile – Based on typical 25-year maintenance plan, using costs from the MTC's StreetSaver® pavement management system
- State Highway: $67,000 – Mid point between cost for Freeway and Local Roadway

Capital Investment Useful Life

This section documents the capital asset useful life assumptions used to annualize capital cost. The useful life of the entire project is generally determined by the component with the largest contribution to capital cost. For comparative purposes, the useful life assumptions were simplified and leveled.

- Roadway projects – 20 years (based on FHWA guidance)
- Local bus – 14 years (based on regional capital priorities process)
- Express bus over-the-road coaches – 18 years (regional capital priorities process)
- Bus rapid transit – 20 years (since a big portion of BRT projects involve roadway improvements)

4. Quantitative Assessment: Methods for Regional Programs

This section documents the key assumptions for the MTC Regional Program Benefit-Cost calculations. The following projects are evaluated:

- Regional Bicycle Network
- Transportation for Livable Communities (TLC)
- Transportation for Livable Communities with Transit Oriented Development Emphasis
- Lifeline Transportation Program
- Means-Based Transit Discount Program (new proposal for Transportation 2035)
- Local Streets and Roads Maintenance Shortfall
- Transit Capital Shortfall
- Climate Protection Program (new proposal for Transportation 2035)

For projects expected to impact vehicle miles traveled (VMT), such as the Regional Bicycle Network and TLC, MTC staff have estimated changes in VMT based on available research as described below. Estimates of changes in delay, emissions, and vehicle operating costs are made based on the ratios of year 2035 regional total VMT to each of those factors. The ratios used in this analysis are based on the year 2035 No Project forecast for the fall 2007 Vision Analysis. These relationships are documented in Table 8. Table 8 also documents the valuations assigned to each benefit.

Savings in private costs (vehicle ownership and transit fares) are the principal benefits estimated for the Lifeline and Means-Based Discount programs.

Savings in public and private costs are the principal benefits estimated for the maintenance shortfall programs.

Some commonly used abbreviations in this section include:

BATS	Year 2000 Bay Area Household Travel Survey
CoCs	Communities of Concern – low-income and minority communities defined in the Equity Analysis for the Transportation 2030 Plan
HH	household
HIP	MTC's Housing Incentive Program
MT	Metric tonnes
RBN	Regional Bicycle Network
SR2S	Safe Routes to School Program (State Funded)
SR2T	Safe Routes to Transit Program (Regional Measure 2)
STARS	Station Area Residents Survey Report (September 2006), analysis of data collected in the Year 2000 Bay Area Household Travel Survey
TLC	MTC's Transportation for Livable Communities
TOD	Transit Oriented Development
VMT	vehicle miles traveled

Regional Bike Network

VMT Reduction

Formula:
(0.1 to 0.2) x (448,000 Year 2035 daily bike trips) x (0.63 auto trips reduced per each new bike trip) x (4.0 miles per auto trip reduced) x (352 days per year)

References and Assumptions:

- For 10% increase in bike trips: Orenstein Marla R., Gutierrez, Nicolas, Rice, Thomas M., Cooper, Jill F., Ragland David R. 2007. Safe Routes to School- Safety and Mobility Analysis. Institute of Transportation Studies. Berkeley

- For 20% increase in bike trips due to new facilities: McDonald, A.A., Macbeth, A.G., Ribeiro, K.M., & Mallett, D.S., 2007. Estimating Demand for New Cycling Facilities in New Zealand. Land Transport NZ Research Report 340. 124 pp.

Note: This is a change from the originally proposed methodology, which was to consider observed growth bike trip growth rates relative to regional network bike mileage over the past 6 years. After further review, that approach seemed unreliable, as the scale of improvements proposed was considerably larger than any past increase in bike network mileage. A simpler approach of estimated future growth in bike trips was pursued. This approach is similar to that used for the Safe Route to Schools element of the Climate Change program.

The 10% to 20% range is also consistent with the range tested for the Safe Route to Schools element of the Climate Change program.

Transportation for Livable Communities (TLC)

Note: This calculation assumes the TLC program continues its past focus – improvements that support walking and bicycle access to public transit hubs and stations, major activity centers and neighborhood commercial districts as a way of fostering community vitality.

VMT Reduction

Formula:
(20 VMT/HH/day) x (0.03 VMT reduction factor) x (365 days/yr) x (9,000 households impacted by TLC capital projects annual investment) x (25 years of investments)

References and Assumptions:

- Average VMT/HH/day for households within half mile of rail or ferry terminals = 20 (2000 MTC Bay Area Travel Survey)

- Factor for reduction in VMT = 0.03 (MTC staff estimate based on 11/5/03 technical memorandum from Fehr and Peers that documents the following reductions in VMT based on the 3 'D's:
    - Density = .11 (resulting from increased residential densities)
    - Diversity = .12 (resulting from greater mixing of residential, commercial and retail uses)
    - Design = .09 (incorporating 3 factors – street network density, sidewalk completeness and route directness)

- Households Impacted in 2035 = (avg. # of households within ½ mile station areas in 2035 = 2500) x (30 percent transit share of households within station area) x (avg of 12 TLC capital projects per year at avg. cost of $5 million per project) = 9,000 households

- 2,500 households per station area = staff estimate based on 2000 estimate of 1800 households per station area (source: MTC Station Area Residents Survey Report, September 2006, using data from the 2000 Bay Area Travel Survey) and assumed 33% capture of new households through 2035.

- 30 percent "transit using households" within station area = conservative estimate based on MTC Station Area Residents Survey Report, September 2006, report showing 48 percent of all households within ½ mile of transit utilized transit at least once during two day survey period. Assumed that not all of these households will receive "benefit" from individual TLC project.

Auto Ownership Reduction

Auto ownership reductions – while indirectly associated with the 3 'D's above – were not included in the methodology associated with the Fehr and Peers memo referenced above.

Transportation for Livable Communities (TLC) with emphasis on Transit Oriented Development (TOD)

Note: The "TOD" program calculation is for illustrative purposes based on a potential option for TLC funding to be used to facilitate the development of specific transit-oriented developments. This is a staff recommendation considered by the Commission in the course of developing the Transportation 2035 Plan.

VMT Reduction

Formula:
(36 VMT/HH/day – 20 VMT/HH/day) x (365 days/yr) x (2400 housing units facilitated with TLC funding per year) x (25 years of investment) x (47% TLC share of total public investment in TOD developments)

References and Assumptions:

- VMT/HH/Day – MTC 2000 Bay Area Travel Survey where households within ½ mile of station areas account for 20 VMT/day and the regional average per household is 36 VMT/day.

- Housing units facilitated with TLC funding in 2035 – based on $60 million in annual funding. Estimated 12 projects per year at $5 million per project with an average project size of 200 units (first two cycles of housing projects under HIP averaged roughly 300 units per project based on 2008 TLC evaluation report).

- TLC funding as total share of total public investment = 47% – based on TLC project sponsor surveys completed as part of 2008 TLC evaluation report.

Auto Ownership Reduction

Formula:
(1.77 autos per household regional average – 1.14 autos per household within ½ mile of transit) x (2,400 housing units facilitated with TLC funding in 2035) x (24% TLC share of total public investment in TOD developments) x ($5,628 annual cost per vehicle in 2035)

Sources and References:

- See above.
- Cost per vehicle from Table H9 for all households, MTC's Travel Forecasts for the SF Bay Area 2009 RTP Vision 2035 Analysis, November 2007.

Lifeline

VMT Reduction

Staff has assumed no net benefit for VMT reduction through Lifeline program investments.

Auto Ownership Reduction

Formula:
(1.6 autos per household in urban areas with good transit access – 1.57 autos per household in urban areas with more limited transit access) x (189,788 low-income households in areas with urban densities in 2035) x (10% of those households who are able to postpone purchase of additional autos) x ($3,159 annual cost per vehicle in 2035)

References and Assumptions:

- Autos per household – from 2000 Bay Area Travel Survey (BATS) and Station Area Residents Survey (STARS) report. Figures represent households who live in urban densities comparing those who live ½ mile to 1 mile from rail transit vs. those who live greater than 1 mile from rail transit.

- # of Households Served:
  2000 Community of Concern households = 709,168
  2030 Community of Concern households = 981,590
  2035 Estimated Community of Concern households = 1,026,994 (factored up from 2000-2030 growth rate)

- 10% of low-income households with urban densities are able to postpone purchase an additional auto through better mobility options (postponing need to move from from zero to one auto, or from one to two autos per household etc.)[6]

- 189,788 low-income households in urban Communities of Concern (CoCs)
  - 56% of CoCs have urban densities
  - 33% of CoCs are low-income
  - ((1,026,994 CoC households in 2035) x (56% in urban densities)) x (33% low-income households within CoCs) = 189,788 low-income households in urban CoCs
- Cost per vehicle from Table H9 fro low-income households only, MTC's Travel Forecasts for the SF Bay Area 2009 RTP Vision 2035 Analysis, November 2007.

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[6] The percent of households able to postpone purchase of additional auto (10%) is a MTC staff estimate. It should be noted there is very little research or evidence available to suggest that greater transit and mobility options for low-income residents – either through Lifeline investments or otherwise – have led to the postponement of auto purchases.

Means Based Transit Fare Discount

VMT Reduction

Staff has assumed no net benefit for VMT reduction through Means Based Transit Fare Discount.

Auto Ownership Reduction

Staff has assumed no reduction in auto ownership through this program.

Aggregate Transit Fare Reduction

Formula:
($45 million total funding per year) / (181,755 transit riding households with annual income < $15,000) = ($248 savings per household per year)

References and Assumptions:

- Treats discount as a direct subsidy, with no overhead.
- Transit riding households with income < $15 K estimated by MTC staff based on figures from MTC's 2006 transit demographic survey

Reduction in Household Transportation Expenditures

Formula:
Average share of income spent on transportation for households earning less than $15,000 per year (US total based on Consumer Expenditure Survey) = 35.9%

Average share of income spent on transportation after subsidy = [$2,934 - $248 avg. subsidy for means based transit fare discount] / [avg. income of households earning less than $15,000 per year = $8,150] = 32.9%

References and Assumptions:

- Current household expenditures on transportation from Consumer Expenditure Survey 2004/05

Local Streets and Roads Maintenance

Cost Savings

The benefit derived from reducing the costs associated with deferring maintenance through increased levels of regional investment was measured by calculating the change in "maintenance backlog" between the first year of the analysis and the last year, for several regional investment scenarios.

Formula:
(Net 25-year change in maintenance backlog without regional investment in maintenance) – (Net 25-year change in maintenance backlog with regional investment = $4.1 B to $21.4B in deferred maintenance cost savings over 25-years

Extra Vehicle Operating Costs (EVOC) Savings

Research shows that drivers incur additional vehicle operating and maintenance expense as a result of driving on poorly maintained roadways. The EVOC benefit can be measured as the amount of private costs saved over time by reducing the rate of deterioration in pavement condition with a greater level of regional investment.

Formula:
(25-year EVOC without regional investment in maintenance) – (25-year EVOC cost with regional investment in maintenance) = $5.4 B to $17.8B in EVOC cost savings over 25-years

References and Assumptions:

- Deferred maintenance cost data: StreetSaver® Pavement Management System database, City of San Rafael, 2006

- Existing revenue data: 2007 Local Street and Road Needs, Revenue Survey data

- EVOC costs associated with driving on poor pavement: *Keep Both Hands on the Wheel: Metro Areas with the Roughest Rides and Strategies to Make Our Roads Smoother*, The Road Information Program (TRIP), March, 2008. The EVOC value provided by TRIP was divided in half to account for the fact that the costs they reported included those incurred on state highways as well as local roads. It was then assumed that for every change of one point in pavement condition index (PCI), there would be a corresponding change of 5% in EVOC. The ratio of licensed drivers to registered vehicles was assumed to be 1:1 and growth in registered vehicles was estimated at 1% per year.

Transit Capital Maintenance

Cost Savings

Reflects: 1) the public benefit of avoided increases in rehabilitation and maintenance costs, and 2) the private benefit for passengers of avoided delays due to increased reliability, if transit capital assets are replaced and rehabilitated in a timely manner. Reflects only a small portion of the benefits of transit capital maintenance; does not include other benefits of maintaining an operable transit system, such as increased system reliability leading to increased ridership, reduced congestion, reduced emissions, and increased mobility.

Formula:

Benefit-cost ratio for public cost savings:
(Projected replacement, rehabilitation and maintenance costs if transit capital assets are operated to 150% of their standard useful lives and run to failure before repair) / (Projected replacement, rehabilitation and maintenance costs if assets are replaced at 100% of their standard useful lives and receive scheduled maintenance and rehabilitation) = 1.4

This is $400 in avoided additional costs for every $1,000 invested in transit capital replacement and rehab.

Benefit-cost ratio for benefit:
(0.08 hours delay) x (486,535,000 regional passenger trips/year) x ($13.50/hour value of passenger time) / ($1,558,000,000 average annual transit capital replacement costs) = 0.35.

Combined public and private benefit-cost = 1.4 + .35 = 1.75

References and Assumptions:

- Assume average of five minutes of delay/passenger due to reduced availability and reliability of transit vehicles if vehicles are not rehabbed and replaced on schedule.

Surprisingly little research has been published that quantifies the benefits of replacing and rehabilitating transit capital assets. The public benefit of avoided increases in rehabilitation and maintenance costs was derived from an Army Corps of Engineers study which compared rehabilitation and maintenance costs for facilities over the life of the facility under two scenarios: Best Practices (performing all scheduled rehabilitation and maintenance), and Run-To-Failure (rehab or repair only after component failure). At 150% of useful life (i.e., if the facility was operated 50% longer than the normal useful life before replacement), the cumulative rehab and maintenance costs under Run-To-Failure were 313% of cumulative costs at 100% of useful life under Best Practices. This differential captures the effects both of operating the facility beyond its standard useful life and of failing to perform scheduled maintenance and rehabilitation, which is appropriate since the transit capital program includes both replacement and rehabilitation costs. Higher rehab and maintenance costs are offset by lower replacement costs (from operating assets for a 50% longer period before replacement). Total capital costs (replacement + rehab +

maintenance) under the 150% of useful life/Run-To-Failure scenario are estimated to be 140% of total capital costs under the 100% of useful life/Best Practices scenario, i.e., $400 in avoided additional costs for every $1,000 invested in transit capital replacement and rehab.

Failure to adequately maintain, rehabilitate and replace transit assets would lead to reduced availability and reliability of transit vehicles, causing delays in transit service for passengers. No research or data that quantifies this connection was available, so staff made a conservative assumption of an average of five minutes of delay per passenger if transit assets are not adequately maintained and replaced. This was multiplied by the annual number of passenger trips and the standard value of time from the regional planning model to derive the total annual private cost of delay ($547 million). The B/C ratio is the total annual cost of delay divided by the average annual cost of transit capital needs.

Regional Transportation Climate Action Campaign

Purpose:

- Develop initial estimates for CO_2 reductions from various elements of the Transportation Climate Action Campaign and for the program as a whole
- Develop related cost effectiveness estimates
- Lay out general methodologies
- Provide initial set of assumptions used in calculations

General: Due to the general nature of many elements of the program, it was necessary to make a number of assumptions for the calculations below. The approach to the estimates is consistent with earlier Brittle/Riordan CO_2 transportation inventory and strategy analyses. Since this is a five year program, CO_2 emission reductions are estimated for 2015. To put these estimates in a larger context, the CO_2 reductions are also shown as a percent of total 2015 transportation emissions (from all light duty vehicles and trucks). No estimates are made for the Climate Grant Program, as the specific projects are not known at this time.

Additional backup for the calculations is also provided

Public Information Campaign
Elements: media information, employer engagement, outreach to schools, cities, etc.
Assumptions:

- $25 m for Campaign over five years
- Education will lead to smarter driving and better vehicle maintenance
- People will drive less aggressively, and more drivers will observe posted freeway speed limits
- Vehicle owners will pay greater attention to regular tune ups, correct tire pressure, clean air filters, regular oil changes, judicious use of AC, etc.
- People will plan their trips to consolidate stops and save fuel
- The Campaign will result in changes to people's behavior affecting 10% to 20% of daily VMT in 2015 (conservative estimate, but many individuals are probably already doing some of the "smart" measures)
- For the VMT affected, better maintenance will result in a 2-3% improvement in fuel economy
- For the VMT affected, smarter driving will result in an additional 2-6% in fuel economy
- Elements of the Campaign would probably also address changing commuter travel behavior; any CO_2 reductions from changes in commuter mode choice would be in addition to the estimated CO_2 reductions below.

Estimated Daily CO_2 reductions (and % of 2015 transportation inventory):

- Low VMT impact/effectiveness: **316 MT** (0.3%)
- High VMT impact/effectiveness: **1,421 MT** (1.5%)

Cost Effectiveness ($ per MT reduced): **$16-$72**

Incentives Program
Elements: rebates for tune ups, rebates for low rolling resistance replacement tires, rebates for tire pressure monitors, buy back of older gas guzzlers, and other (TBD). *Note*: The analysis below looks at several incentive options, as if all the funds were dedicated to one of these options. In reality, multiple incentives would probably be offered.
Assumptions:

- $5 million for incentives over 5 years
- $50 rebates =100,000 sets of Low Rolling Resistance Replacement tires
- $30 tire pressure monitors = 166,667 monitor kits installed
- $500 tune ups for most out of tune cars = 10,000 cars better tuned
- $1000 to buy back early model SUVs = 5,000 older SUVs replaced with better MPG cars

Estimated Daily CO2 Reductions (and % of 2015 inventory)

- LRR tires: **32.1 MT** (.03%)
- Tire pressure monitors: **18.5 MT** (.02%)
- Tune ups: **6.6 MT** (.007%)
- Vehicle buy back: **18.1 MT** (.02%)

Cost Effectiveness/LRR tire ($ per MT reduced): **$141**

Cost Effectiveness/Tire Pressure Monitors ($ per MT reduced): **$154**

Cost Effectiveness/Tune ups ($ per MT reduced): **$1,036**

Cost Effectiveness/Vehicle Buy Back ($ per MT reduced): **$253**

Telecommuting Pilot Program
Elements: outreach and assistance to employers to set up new telecommuting options for their employees
Assumptions:

- $2 m available for five years; split between telecommuting ($1m) and expanded employer outreach ($1m)
- Pilot program generates 12,500 new telecommuters (employees who would work at home at least 1 day per week); based on Santa Barbara and Washington DC programs (TAG)
- CO2 reductions reflect former mode of getting to work and average number of days per week employees telecommute; based on data from Resources for the Future report on telecommuting programs in 5 cities, December 2004)
- Expanded employer engagement would also generate additional emission reductions, but these have not been estimated because details of such a program have not been defined

Estimated Daily CO2 reductions (and % of 2015 inventory)

- **46.6MT** (.05%)

Cost Effectiveness ($ per MT reduced): **$29**

Transit Priority Program
Elements: Transit signal priority, bus stop relocations, bus bulbs, queue jumper/HOV lanes, improved passenger boarding areas, etc.
Assumptions:

- $50 m for five years
- Program improvements described above would reduce bus travel times/improve reliability (reduced headways would create additional benefits, but are not assumed to be part of this program)
- Program would be applied to 10 major Rapid corridors ($5 m per corridor)
- Each corridor would generate 3,000 new daily riders in 2015
- Estimated emission reductions account for new riders who are transit dependent (do not own a car)
- Estimated CO_2 reductions do not assume any offsetting CO_2 emissions from new riders accessing transit by auto

Estimated Daily CO2 reductions:

- **25 MT** (.03%)

Cost Effectiveness ($ per MT reduced): **$2,083**

Safe Routes to Schools
Elements: Infrastructure (sidewalks, crosswalks, traffic controls, signage, etc.), faculty and student education, and standardized training, promotional materials, and curriculums.
Assumptions:

- $25 m available
- Benefits are largely for grades K-8
- Program is regional, affecting all 9 counties
- Major infrastructure improvements generally concentrated within 2 miles of school, but education and training would affect all school trips
- Forecasted 2015 Grade School trips from MTC model
- Assumes an average 10% to 20% increase in the number of K-8 students biking and walking to school in 2015

Estimated Daily CO2 Reductions:

- **18 to 36 MT** (.02 to .04%)

Cost Effectiveness ($ per MT reduced): **$1,300 to $2,600**

Safe Routes to Transit
Elements: Focuses on bike and pedestrian access to regional transit services, e.g., new bike and pedestrian routes, safety measures for bike and pedestrian routes, improved signage, bike lockers at transit stations, bikes on transit, etc. Program would not have same restrictions as current legislation.

- $50 million for five years

- Data on relationships between these types of access programs and increases in transit ridership and access mode share difficult to find; therefore, only mode share is addressed in calculation (but substantial gains in transit ridership, as contained in MTC forecasts, are included in the calculation)
- Evaluation results are based on increasing bike/walk shares to BART and Caltrain

Estimated Daily CO2 Reductions:
- **5.5 MT** (.006%)

Cost Effectiveness ($ per MT reduced): **$9,470**

Plug In Hybrid Promotion
Elements: Outreach to promote production and use of Plug Ins.
Assumptions:
- $2 m in staff time over five years
- Assume that regional promotion effort results in at least 100 new Plug Ins in the region (low estimate--essentially related to the opportunity cost of funding 100 conversions from hybrid to Plug In at $20,000 per conversion)
- Alternatively, assume promotion more successful and generates 1000 new Plug Ins over five years
- Assume Plug In replaces a conventional gasoline car with 2015 fuel economy equal to fleet average for light duty vehicles
- Well to Wheels comparison approach to capture CO2 emissions from electricity generation for Plug In

Estimated CO2 Reduction
- **1 to 11 MT** (negligible to 0.1%)

Cost Effectiveness ($ per MT reduced): **$166 to $1,658**

Grant Program
Elements: Varied, depending on the demonstration project
Assumptions:
- $25 million for 5 years
- Proposed projects will need to pass screening with a minimum CO2 reduction required and/or be shown to be highly cost effective

Estimated Daily CO2 Reductions: **TBD**

GRAND TOTAL
- Total Program CO2 Reductions**:**
  - 420 MT per day (0.4%) to 1,578 MT per day (1.6%)
- Total Program CO2 Cost Effectiveness**:**
  -$94 to $371 dollars per MT of CO2 reduced

Cost Effectiveness

	5 Year Cost	**Low Reduction** (MT for 5 Years)	**High Reduction** (MT for 5 Years)
Public Info	$25,000,000	346,020	1,555,995
Incentives	$5,000,000	4,825	35,455
Telecommute	$1,000,000	34,969	34,969
Transit Priority	$50,000,000	24,000	24,000
SR2S	$25,000,000	9,612	19,224
SR2T	$50,000,000	5,280	5,280
Plug Ins	$2,000,000	1,206	12,060
Total	$158,000,000	425,912	1,686,983

Backup for Calculations for Regional Climate Campaign

General

- 2015 daily VMT for Light Duty Vehicles = 187,849,000 (ARB/EMFAC VMT)
- 2015 daily CO_2 from Transportation (including trucks) = 95,960 Metric Tons (MT) per day
- 2015 average on road mpg for light duty vehicles = 21.1 mpg (adjusted for new CAFÉ standard)
- 19.5 pounds CO_2 per gallon of gasoline which is converted to metric tons (only CO_2 reductions, calculated, not other GHGs)
- Methodology and assumptions consistent with *Transportation Strategies for Reducing CO2 Emissions* (Brittle/Riordan, updated January 2008)
- 2015 travel forecasts from 2005 RTP: *Travel Forecasts for the San Francisco Bay Area 1990 to 2030*, MTC, January 2005; these forecasts have been used for all Brittle/Riordan Climate Change analysis to date and in latest TIP conformity analysis)
- For cost effectiveness calculations, CO_2 reductions are summed over 5 years and divided by 5 year program cost; also, there is a "ramp up" factor for most programs, i.e., only a portion of benefits would be achieved the first year with benefits growing to a maximum in the fifth year. For other programs, all available benefits are captured in the five year span.

Smart Driving and Maintenance

- Daily LDV VMT affected:
  - Low (10%): 18,785,000
  - High (20%): 37,570,000
- CO_2 reductions from Smart Maintenance: 2-3%
  - -using correct motor oil improves fuel economy 1-2%
  - -tuning up a noticeably out of tune vehicle improves fuel economy 4%
  - -replacing a clogged air filter improves fuel economy 10%
  - -properly inflated tires improve fuel economy 2-3%
  - -AC use reduces gas mileage 5-15%
- CO_2 reductions from Smart Driving: 2-6%
  - -driving aggressively reduces fuel economy 5% around town and up to 33% at highway speeds
  - -driving 65 mph instead of 70-75 mph improves fuel economy 13% to 15%
  - -turning off engine when car is idling saves fuel if idling longer than 30 seconds
  - -combining trips allows engine to warm up and be most efficient, and reduces excessive travel distance

Consumer Incentives: Low Rolling Resistance replacement tires

- 15,000 miles per vehicle per year
- 100,000 cars equipped with LRR tires over five years
- Tires last 45,000 miles
- LRR replacement tires improve fuel economy 2%

Consumer Incentives: Tire pressure monitors on the tires

- Keeping tires properly inflated will improve fuel economy 2%
- 167,000 vehicles equipped with tire pressure monitors over 5 years
- 15,000 miles per vehicle per year, but CO2 benefits reduced since under inflated tires would probably be corrected at a regular 5,000 mile tune up or oil change

Consumer Incentives: Vehicle Buy Back

- Assumes buy back would be for older cars with the worst mpg, e.g., early SUVs, with mpg of around 14
- Older cars are driven less; assume 5,000 miles per year
- 14 mpg vehicle replaced with 24 mpg vehicle (a condition for buy back)
- For cost effectiveness, assume 3 years of driving left on older vehicle

Consumer Incentives: Tune ups

- 10,000 cars that are noticeably out of tune get major tune ups
- Cars driven 15,000 miles per year
- Tune up improves fuel economy 4% (DOE website)
- For cost effectiveness, assume a major tune up lasts 30,000 miles

Telecommuting

- Pilot program creates 12,500 new teleworkers ($80 per new participant, which is average of two TAG programs in Washington DC and Santa Barbara, CA)
- These workers telecommute an average 1.8 days a week
- Average one way commute is 16 miles (Bay Area average for 2015 commute trip is 12.3 miles)
- 77% of teleworkers would have driven to work alone; no emission reductions assumed for the other 23% (carpoolers, use transit, or bike/walk as former commute modes)
- For cost effectiveness, assume 250 working days per year

Transit Priority Program

- Prior AC Transit Enhanced Bus study used as basis for estimated short term ridership gains
- Assume investments concentrated in 10 corridors with average gain of 3,000 new daily transit riders per corridor in 2015 (30,000 total, which equates to about 1.9% of forecasted 2015 boardings for Muni, AC, VTA, and Samtrans)
- Average trip length for these passengers is 3.3 miles
- CO2 benefits reduced 40% due to portion of new riders who don't own a car (ARB guidance assumes a default 50% reduction)
- For cost effectiveness, a ridership annualization factor of 320 is used to go from daily to annual CO2 reductions

Safe Routes to Schools

- MTC forecasts used for number of Grade School bike/walk trips in 2015
  - -320,589 forecasted Grade School walk trips in 2015
  - -51,575 forecasted Grade School bike trips in 2015

- Assume 10%-20% increase regionally in bike/walk trips
- All increases come from single students riding in autos to school
- Assume a walk trip replaces a one mile auto trip and a bike trip replaces a 2 mile auto trip
- For cost effectiveness, use 180 school days per year

Safe Routes to Transit

- For BART, assume bike share of access trips increases from 2% to 3% and walk share increases from 23% to 24.5% (similar to adopted goals from Access Plan)
- For Caltrain, use current bike share and increase by 1%; use walk access share goals similar to BART's
- 2015 BART ridership: 440,000 riders per day (MTC forecast)
- 2015 Caltrain ridership: 45,000 riders per day (MTC forecast)
- Bike access replaces a single occupant car trip of 2 miles
- Walk access replaces a single occupant car trip of 0.5 miles
- For cost effectiveness, use ridership annualization factor of 320

Plug In Hybrid

- Promotion efforts will result in at least 100 Plug Ins around the region (equivalent to $2 m divided by $20,000 per conversion from hybrid to Plug In) and a maximum of 1,000 Plug Ins over five years
- 15,000 miles driven per year
- 50% less GHGs compared to conventional gasoline vehicle (Well to Wheels comparison; based on ARB calculation for Pavley bill that Plug Ins would reduce lifetime CO2 equivalent emissions by 50% compared to conventional gasoline vehicles)

5. Quantitative Assessment: Cost per Low-Income Household Served by Transit –Assumptions and Methodology

Background

The overall approach to the quantitative evaluation is to compare project costs with benefits, where the benefits measured are correlated with the adopted Performance Objectives. Through discussions with members of MTC's Minority Citizens Advisory Committee and others, MTC staff debated the merits of various measures to reflect the Affordability Performance Objective. Ultimately, staff recommended and the Commission approved "Cost per Low-Income Household Served" as a trial measure for the transit projects subject to the performance assessment. There was general agreement this measure posed some challenges but also offered a reasonable first step.

An often-express concern about the measure related to estimating the number of low-income households that might actually use a given transit improvement. It is simplistic to assume all low-income households on walking distance will use a given transit service; the service may not serve their destinations when needed and, in some cases, may be unaffordable. Thus, the methodology includes a step to adjust the total number of low-income households based on household travel survey data reflecting transit usage rates by income level and geography.

Assumptions and Methodology

- The metric is applied only to the thirteen transit projects subject to the quantitative project assessment. Note that by Commission policy, projects considered "Committed" are not subject to the project assessment. This includes Resolution 3434 transit expansion projects and projects that are fully funded. (See Part 1 of this Appendix for criteria defining projects subject to analysis.)
- The measure was calculated as [Annualized Project Cost] divided by [Number of Low-Income Households Served in 2035]
- Annualized project cost is one year of the net operating costs plus the total capital cost divided by the expected life of the project capital assets (14 years for buses and 20 years for rail projects).
- The number of low-income households served is defined as the number of transit-using low-income households within walking distance of transit stops in 2035. To address the concerns outlined above, this is estimated as follows:
    (a) Transit-using low-income households were estimated based on MTC's year 2000 Bay Area Household Travel Survey (BATS2000). The share of households reporting transit used in a two-day period was estimated by county-of-residence, by income level, and by urban density levels. These fractions were then applied to ABAG's Projections 2007 year 2035 estimates of low-income households at the MTC travel analysis zone level.
    (b) Geographic Information Systems (GIS) software was used to create one-half mile walkable buffers around the transit project stops. The software was then used to

extract the number of transit-using low-income households within a one-half mile walkable buffer of the transit route.

6. Tables

Table B-1: Benefit/Cost Summary

RTP ID#	Project Title	County	Invest Type [1]	Project Capital Cost ('07$M)	Total Annual Benefit ('07$M)	Annual VMT Reduced (mill) [2]	Annual CO_2 Reduced (tons) [2]	Cost Per VMT Reduced ('07$) [2]	Cost Per US Ton CO_2 reduced ('07$) [2]	Benefit/ Cost [3]	Notes
B/C Ratio of 10 or higher											
21992, 230111	AC Transit Transit Priority Measures (TPM) and Corridor Improvements* *AC Transit submitted additional TPM components consisting of Grand/Maritime HOT on-ramp and Bay Bridge contraflow lane, which are not included in this assessment. Preliminary off-model analysis suggests these components have significant benefits for transit riders and merit further examination	Alameda	NC/V	$38.3	$56.5	12.1	720	$0.2	$2,700	30	
230419	Freeway Performance Initiative	Bay Area Region/ Multi-County	NC	$600.0	$1,593.5	-66.2	202,000	-$0.8	$300	28	
Various	Santa Clara HOT Corridors: US 101, SR 87, SR 85, SR 237, I-880, I-280, I-680 (RTP ID#230248, 230404, 230254, 230259, 230258, 230278, 230280,	Santa Clara	NC	$777.9	$1,030.9	310.7	246,000	$0.1	$200	25	
230369, 230610	Regional HOT Network and express bus enhancement	Multi-County	NC	$3,281.6	$3,795.9	781.5	610,000	$0.3	$300	18	
22420	Bus Rapid Transit (BRT)/Transit Preferential Streets (TPS) (sales tax project)	San Francisco	NC	$418.2	$350.5	50.2	4,500	$0.4	$4,650	17	
22776	Route 84 Expressway Widening	Alameda	NC	$124.0	$90.8	5.9	13,000	$1.2	$500	13	
230161	Van Ness Avenue BRT	San Francisco	NC	$76.1	$39.6	7.2	200	$0.5	$19,000	10	
B/C Ratio of 5 to 9											
22657	I-580 (Altamont Pass) Westbound Truck Climbing Lane	Alameda	V	$75.6	$31.8	-0.5	-4,900	-$7.6	-$800	8	
21902, 230413, 98154, 98147*	US 101 SB HOV lane extension (Railroad/ Pepper to Petaluma River Bridge) and Marin-Sonoma Narrows (SB: Petaluma River Bridge to Rowland; NB: north of Atherton Avenue to north of East Washington Ave)	Multi-County/ Bay Area Region	NC	$926.8	$378.7	-36.6	-2,090	-$1.3	-$24,000	8	
Various	Alameda HOT Corridors: I-680, I-580, I-880, I-238 (RTP ID#230088, 230089, 230609, 22042, 22668, 22664, 230241)	Alameda	NC	$1,550.9	$663.4	188.6	130,000	$0.5	$700	7	
230164	Geary Boulevard BRT	San Francisco	NC	$190.5	$64.2	6.9	200	$1.4	$47,600	7	
22700	Parallel corridor north of I-80 from Red Top Road to Abernathy Road (the western section extends from the railroad crossing on Red Top Road	Solano	NC	$68.0	$25.3	7.7	5,000	$0.5	$800	6	
22351*	I-680 NB HOV lane extensions (North Main to SR-242 and north of Benicia Bridge to I-80) and HOV lane connector NB I-680 to EB I-80	Multi-County	V	$193.0	$74.3	-18.3	2,800	-$0.7	$4,400	6	
21902, 230413*	US 101 SB HOV lane extension (Railroad/ Pepper to Petaluma River Bridge)	Sonoma	NC	$124.0	$36.6	-4.2	-7,140	-$1.7	-$980	5	
22145, 22958	SR 237/US 101 improvements: a) Widen westbound Route 237 on-ramp to northbound US 101 to 2 lanes and add auxiliary lane on northbound US 101 from Route 237 on-ramp to… b) US 101 southbound to eastbound Route 237 connector improvements	Santa Clara	NC/V	$73.0	$20.3	-0.1	3,900	-$47.6	$1,000	5	
22013	Eastbound I-580 Truck Climbing Lane	Alameda	NC	$64.2	$17.6	-0.5	-3,300	-$7.4	-$1,000	5	
230569*	I-80 EB & WB HOV lanes between Airbase Parkway and I-505	Solano	NC	$132.0	$45.8	-22.9	-1,000	-$0.4	-$10,000	5	
Various	Local Streets and Roadway Maintenance Shortfall	Regional	NC	$8,208.0	$1,573.0	N/A	N/A	N/A	N/A	5	B/C based on dollars saved by performing maintenance on time. Average annual benefit for high funding scenario
94151	Construct 4-lane Jepson Parkway from Route 12 to Leisure Town Road	Solano	NC	$182.0	$46.6	-2.0	15,000	-$5.1	$700	5	

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B/C Ratio of 1 to 4											
22667	BART to Livermore: Tri-Valley rail extension from Dublin/Pleasanton BART Station to Greenville Road in the I-580 median	Alameda	NC	$1,042.0	$187.7	6.6	1,000	$6.8	$44,600	4	
230477	SR 12 Improvements: Phase 1	Solano	NC	$100.0	$21.4	-13.8	-4,700	-$0.4	-$1,300	4	
230060	Marin County Local Transit Enhancement on 6 Key Corridors	Marin	NC	$27.3	$6.9	1.9	200	$1.0	$9,750	4	
230326, 230327	I-80/I-680/SR12 Interchange: Phase 1 plus Balance of Project	Solano	V	$1,183.0	$209.9	-7.2	-2,200	-$8.7	-$28,000	3	
22346	Express bus service expansion along I-580 corridor	Contra Costa	V	$50.0	$9.0	0.4	30	$7.4	$108,000	3	
230326	I-80/I-680/SR12 Interchange - Phase 1	Solano	NC	$513.0	$67.2	1.3	-2,100	$21.4	-$13,000	2	
230570*	I-80 EB & WB HOV lanes between Carquinez Bridge and SR-37	Solano	NC	$105.0	$14.3	-3.7	-620	-$1.7	-$10,000	2	
n/a	I-80 add 5th mixed-flow lane (EB: SR-12 East to Airbase Parkway and WB: West Texas to SR-12 East)	Solano	N/A	$69.8	$8.7	-0.8	-2,582	-$4.7	-$1,500	2	
21714	SR 25/Santa Teresa Boulevard/US 101 Interchange (includes US 101 widening between Monterey Road and SR 25 and connection to Santa	Santa Clara	NC	$233.0	$26.0	7.2	7,500	$1.7	$1,600	2	
B/C Ratio of 1 to 4, cont.											
Various	Transit Capital Shortfall	Regional	NC	$11,199.0	$783.9	N/A	N/A	N/A	N/A	2	B/C based on dollars saved by performing maintenance on time. Average annual benefit for high funding scenario
21011	Transportation for Livable Communities + (TOD emphasis)	Regional	NC	$1,500.0	$129.4	164.7	94,000	$0.5	$800	2	B/C based pivots off estimated VMT reduction
94644	Route 92 westbound slow vehicle lane between Route 35 and I-280	San Mateo	NC	$82.0	$8.4	-0.3	3,800	-$12.8	$1,100	2	
21612	Improvement of Dumbarton Bridge access to US 101	San Mateo	NC	$317.0	$27.0	1.3	10,000	$11.9	$1,590	2	
230403	US 101 Widening to 6-lane Freeway: SR 25 to SR 129	Santa Clara	V	$170.0	$15.4	0.5	200	$17.9	$45,800	2	
230496	SR 12 Improvements: Phase 2	Solano	NC	$150.0	$15.0	-0.8	-4,000	-$11.0	-$2,300	2	
230271	I-80 Express Bus Service	Alameda	NC	$70.0	$12.6	2.0	100	$4.2	$81,800	2	
21030	I-580/US 101 interchange improvements and new freeway-to-freeway connector from northbound US 101 to eastbound I-580	Marin	V	$98.0	$7.4	0.4	2,000	$11.6	$2,500	2	
22516	Enhance Capitol Corridor regional rail service (West Contra Costa and Solano cou	Contra Costa	V	$70.0	$11.4	7.2	1,000	$1.0	$7,600	2	
22415	Expand historic streetcar service	San Francisco	NC	$8.2	$2.2	0.1	3	$13.0	$466,000	2	B/C is for E-line upgrade only. Does not reflect F-line extension
21205, 22350	I-680/Route 4 interchange (Phase 1, 2 and 3) and (Phases 4 and 5) and HOV flyover ramps	Contra Costa	NC/V	$320.2	$21.9	-7.9	-1,100	-$2.1	-$15,000	1	
22162	Route 237 westbound to Route 85 southbound connector ramp	Santa Clara	NC	$37.0	$2.6	-1.3	-590	-$1.5	-$3,300	1	
94506	East-West Connector Project in North Fremont and Union City	Alameda	NC	$150.0	$8.7	-10.8	-300	-$0.8	-$27,000	1	
230287	Goods Movement Emissions Reduction Project	Regional	NC	$106.5	$8.1	N/A	2,200	N/A	$6,100	1	Benefit based on CO2 and particulate emissions.
22400	Construct Route 239 from Brentwood to Tracy Expressway	Contra Costa	V	$200.0	$11.2	-7.8	6,100	-$1.5	$1,900	1	
230099	I-580/I-680 Improvements (NB I-680 to WB I-580)	Alameda	NC	$392.5	$19.0	0.4	200	$52.3	$98,300	1	
230294	New SR 152 Alignment: SR 156 to US 101	Santa Clara	V	$350.0	$15.8	-2.0	18,000	-$9.5	$1,000	1	
22605, 98222, 230208	SR4 Bypass: a) Segments 1 & 2: widen from 4 to 6 lanes from Sand Creek to Balfour, and widen segment 3 to 4 lane; b) Segment 1: Route 160 freeway-to-freeway connectors to and from the north; and c) Widen from 4 to 6 lanes from Laurel Road to Sand Creek Road	Contra Costa	V/NC/V	$219.0	$10.4	-10.6	-2,500	-$1.2	-$5,100	1	
22343	Express bus service expansion along I-680 corridor, Phase 2	Contra Costa	V	$57.0	$5.5	1.2	80	$5.7	$85,100	1	
21613	Route 92 improvements from San Mateo Bridge to I-280, includes uphill passing lane from US 101 to I-280	San Mateo	NC	$186.2	$7.2	-9.1	-5,600	-$1.1	-$1,700	1	
230207	Geneva/Harney Bus Rapid Tansit	San Francisco	NC	$202.0	$9.0	1.2	30	$10.6	$422,000	1	
230252	Marin County Local Transit Expansion	Marin	NC	$56.0	$12.2	2.7	100	$6.7	$181,000	1	
22981	Widen Route 4 as continuous 4-lane arterial from Marsh Creek Road to San Joaquin County line	Contra Costa	V	$100.0	$3.3	0.1	1,700	$105.5	$3,400	1	

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B/C Ratio of less than 1											
22247	Regional Bicycle Network	Regional	NC	$1,300.0	$34.8	59.2	33,800	$1.1	$1,900	0.5	
230550	Transportation Climate Action Plan	Regional	NC	$184.0	$13.0	N/A	271,200	N/A	$200	0.4	Benefit based only on CO2
230571	I-80 EB & WB HOV Lanes (SR 37 to Red Top Rd.)	Solano	NC	$107.0	$2.4	-3.7	-620	-$1.7	-$10,000	0	
22671	Construct direct HOV connection between southbound I-880 to westbound Route 84 (Dumbarton Bridge approach)	Alameda	NC	$125.0	$0.6	0.3	510	$19.6	$12,300	0	Project is small and model may not reflect full benefits
22423	Lifeline	Regional	NC	$1,600.0	$1.8	N/A	N/A	N/A	N/A	0.03	Benefit based only on reduced auto ownership costs
22352	I-680/Norris Canyon Road HOV direct ramps in San Ramon	Contra Costa	NC	$80.0	-$0.2	-0.2	200	-$21.4	$20,400	0	Project is small and model may not reflect full benefits
94050	Upgrade Route 4 to full freeway from I-80 to Cummings Skyway (Phase 2)	Contra Costa	V	$75.0	-$3.2	-25.2	-14,800	-$0.2	-$300	-1	

Notes
[1] V = Proposed as Vision Investment; NC = Proposed as New Commitment Investment
[2] negative number indicates an increase in VMT or CO_2 emissions
[3] B/C is based on total benefit divided by annualized cost. Refer to the detailed worksheet for annualized cost.
Delay reduction/travel time saving is the single biggest component of benefit, as measured here. B/C can be understood as a cost effectiveness measure for delay reduction and time savings
* Project analyzed may differ slightly from project submitted, as per discussions with the CMAS under the Freeway Performance Initiative corridor studies

Table B-2: Annualized Impact

RTP ID#	Project Title	County	New Transit Riders	Transit In-Vehicle Travel Time	Transit Out-of-Vehicle Travel Time	Vehicle Miles Traveled	Vehicle Hours Delay (Recurrent)	Non-Recurrent Delay (Hours)	Fatality + Injury Collisions	PM2.5 (tons)	PM10 (tons)	CO2 (US tons)	Private Vehicle Operating Costs	Notes
22013	Eastbound I-580 Truck Climbing Lane	Alameda	NA	NA	NA	468,000	-365,000	-173,000	0.2	0.1	0.3	3,300	108,000	
22657	I-580 (Altamont Pass) Westbound Truck Climbing Lane	Alameda	NA	NA	NA	548,000	-585,000	-334,000	0.0	0.2	0.4	4,900	126,000	
22667	BART to Livermore: Tri-Valley rail extension from Dublin/Pleasanton BART Station to Greenville Road in the I-580 median	Alameda	3,906,000	-907,000	-3,390,000	-6,550,000	-91,000	-1,170,000	-1.0	-0.2	-1.1	-1,000	-1,510,000	
22671	Construct direct HOV connection between southbound I-880 to westbound Route 84 (Dumbarton Bridge approach)	Alameda	NA	0	NA	-320,000	-25,200	1,800	-0.7	0.0	-0.2	-510	-73,000	Project is small and model may not reflect full benefits
22776	Route 84 Expressway Widening	Alameda	NA	NA	NA	-5,900,000	-1,480,000	-995,000	-10	-1.2	-3.8	-13,000	-1,400,000	
94506	East-West Connector Project in North Fremont and Union City	Alameda	NA	NA	NA	10,750,000	-460,000	-40,000	-0.5	0.6	4.8	300	2,470,000	
230099	I-580/I-680 Improvements (NB I-680 to WB I-580)	Alameda	NA	NA	NA	-380,000	-910,000	-11,000	-0.2	0.0	-0.2	-200	-86,000	
230271	I-80 Express Bus Service	Alameda	494,000	116,000	-240,000	-1,970,000	-17,000	-104,000	-0.1	0.0	-0.1	-120	-450,000	
21992, 230111	AC Transit Transit Priority Measures (TPM) and Corridor Improvements* *AC Transit submitted additional TPM components consisting of Grand/Maritime HOT on-ramp and Bay Bridge contraflow lane, which are not included in this assessment. Preliminary off-model analysis suggests these components have significant benefits for transit riders and merit further examination.	Alameda	2,359,000	-1,199,000	-100,000	-12,060,000	-77,800	-560,000	-0.8	-0.1	-0.7	-720	-2,800,000	
Various	Alameda HOT Corridors: I-680, I-580, I-880, I-238 (RTP ID#230088, 230089, 230609, 22042, 22668, 22664, 230241)	Alameda	NA	834,000	NA	-188,610,000	-8,046,000	-6,790,000	-140	-21.0	-95.0	-130,000	-43,000,000	
230419	Freeway Performance Initiative	Bay Area Region/ Multi-County	NA	NA	NA	66,221,000	-18,500,000	-21,100,000	67	-12.0	12.8	-200,000	15,200,000	
230369, 230610	Regional HOT Network and express bus enhancement	Bay Area Region/Multi-County	NA	5,143,000	NA	-781,500,000	-46,460,000	-42,100,000	-600	-95.0	-400.0	-610,000	-180,000,000	
22343	Express bus service expansion along I-680 corridor, Phase 2	Contra Costa	165,000	-19,000	-59,000	-1,190,000	-8,500	-51,000	-0.1	0.0	-0.1	-80	-275,000	
22346	Express bus service expansion along I-580 corridor	Contra Costa	1,492,000	-544,000	-39,000	-440,000	-2,400	-5,700	0.0	0.0	0.0	-30	-100,000	
22352	I-680/Norris Canyon Road HOV direct ramps in San Ramon	Contra Costa	NA	-1,200	NA	190,000	9,000	1,800	-0.5	0.0	0.1	-170	43,800	Project is small and model may not reflect full benefits
22400	Construct Route 239 from Brentwood to Tracy Expressway	Contra Costa	NA	NA	NA	7,781,000	-645,000	0	0.0	0.0	3.0	-6,100	1,788,000	
22516	Enhance Capitol Corridor regional rail service (West Contra Costa and Solano counties)	Contra Costa	270,000	-828	-160,000	-7,200,000	-130,000	-34,000	-1.2	-0.2	-1.3	-1,000	-1,700,000	
22981	Widen Route 4 as continuous 4-lane arterial from Marsh Creek Road to San Joaquin County line	Contra Costa	NA	NA	NA	-54,000	-151,000	0	-0.2	-0.1	-0.2	-1,700	-12,000	
94050	Upgrade Route 4 to full freeway from I-80 to Cummings Skyway (Phase 2)	Contra Costa	NA	NA	NA	25,150,000	-58,000	0	-26	2.3	12.1	14,800	5,780,000	
21205, 22350	I-680/Route 4 interchange (Phase 1, 2 and 3) and (Phases 4 and 5) and HOV flyover ramps	Contra Costa	NA	0	NA	7,850,000	-414,000	-273,000	2	0.5	3.5	1,100	1,800,000	
22605, 98222, 230208	SR4 Bypass: a) Segments 1 & 2: widen from 4 to 6 lanes from Sand Creek to Balfour, and widen segment 3 to 4 lane; b) Segment 1: Route 160 freeway-to-freeway connectors to and from the north; and c) Widen from 4 to 6 lanes from Laurel Road to Sand Creek Road	Contra Costa	NA	NA	NA	10,595,000	-503,000	-21,000	-11	0.6	4.8	2,500	2,430,000	
21030	I-580/US 101 interchange improvements and new freeway-to-freeway connector from northbound US 101 to eastbound I-580	Marin	NA	NA	NA	-420,000	-77,000	-94,000	0.0	-0.2	-0.3	-2,000	-97,000	
230060	Marin County Local Transit Enhancement on 6 Key Corridors	Marin	224,000	-264,000	-670	-1,940,000	-11,000	-44,000	-0.2	0.0	-0.2	-160	-450,000	
230252	Marin County Local Transit Expansion	Marin	783,000	-42,000	-270,000	-2,680,000	-17,000	-42,000	-0.2	0.0	-0.1	-120	-617,000	

Table B-2: Annualized Impact

RTP ID#	Project Title	County	New Transit Riders	Transit In-Vehicle Travel Time	Transit Out-of-Vehicle Travel Time	Vehicle Miles Traveled	Vehicle Hours Delay (Recurrent)	Non-Recurrent Delay (Hours)	Fatality + Injury Collisions	PM2.5 (tons)	PM10 (tons)	CO2 (US tons)	Private Vehicle Operating Costs	Notes
21902, 230413, 98154,	US 101 SB HOV lane extension (Railroad/ Pepper to Petaluma River Bridge) and Marin-Sonoma Narrows (SB: Petaluma River Bridge to Rowland; NB: north of Atherton Avenue to north of East Washington Ave)	Multi-County/ Bay Area Region	NA	-76,000	NA	36,600,000	-6,000,000	-4,000,000	2	3.7	31.9	2,090	8,410,000	
22351*	I-680 NB HOV lane extensions (North Main to SR-242 and north of Benicia Bridge to I-80) and HOV lane connector NB I-680 to EB I-80	Multi-County/ Bay Area Region	NA	-2,700	NA	18,336,400	-1,840,000	-773,000	26	0.8	7.9	-2,800	4,210,000	
22415	Expand historic streetcar service	San Francisco	180,000	-95,000	-27,000	-110,000	-200	-840	0.0	0.0	0.0	-3	-25,000	B/C is for E-line upgrade only. Does not reflect F-line extension
22420	Bus Rapid Transit (BRT)/Transit Preferential Streets (TPS) (sales tax project)	San Francisco	13,536,000	-13,097,000	148,000	-50,150,000	-406,000	-2,680,000	-4	-0.9	-4.6	-4,500	-12,000,000	
230161	Van Ness Avenue BRT	San Francisco	3,303,000	-3,095,000	279,000	-7,220,000	-22,000	-69,000	-0.3	0.0	-0.2	-200	-1,660,000	
230164	Geary Boulevard BRT	San Francisco	3,397,000	-4,647,000	26,000	-6,910,000	-11,000	-9,800	-0.3	0.0	-0.2	-190	-1,590,000	
230207	Geneva/Harney Bus Rapid Tansit	San Francisco	461,000	-372,000	-95,000	-1,190,000	-6,400	-14,000	0.0	0.0	0.0	-30	-273,000	
21612	Improvement of Dumbarton Bridge access to US 101	San Mateo	NA	NA	NA	-1,300,000	-1,100,000	-64,000	-11	-0.2	-0.1	-13,000	-305,000	
21613	Route 92 improvements from San Mateo Bridge to I-280, includes uphill passing lane from US 101 to I-280	San Mateo	NA	NA	NA	9,110,000	-144,000	-131,000	4	0.8	4.4	5,600	2,090,000	
94644	Route 92 westbound slow vehicle lane between Route 35 and I-280	San Mateo	NA	NA	NA	335,000	-411,000	0	0.0	-0.3	-0.2	-3,800	76,900	
21714	SR 25/Santa Teresa Boulevard/US 101 Interchange (includes US 101 widening between Monterey Road and SR 25 and connection to Santa Teresa Blvd)	Santa Clara	NA	NA	NA	-7,200,000	-624,000	-155,000	-7	-1.1	-3.9	-7,500	-1,600,000	
22162	Route 237 westbound to Route 85 southbound connector ramp improvements	Santa Clara	NA	NA	NA	1,330,000	-67,000	-28,000	0.0	0.1	0.6	590	305,000	
230294	New SR 152 Alignment: SR 156 to US 101	Santa Clara	NA	NA	NA	1,970,000	-1,655,000	329,200	-9	-1.2	-0.5	-18,000	452,000	
230403	US 101 Widening to 6-lane Freeway: SR 25 to SR 129	Santa Clara	NA	NA	NA	-510,000	-480,000	-54,000	-21	-0.3	-0.5	-230	-120,000	
22145, 22958	SR 237/US 101 improvements: a) Widen westbound Route 237 on-ramp to northbound US 101 to 2 lanes and add auxiliary lane on northbound US 101 from Route 237 on-ramp to… b) US 101 southbound to eastbound Route 237 connector improvements	Santa Clara	NA	NA	NA	82,300	-367,000	-214,000	-2	-0.3	-0.3	-3,900	18,900	
Various	Santa Clara HOT Corridors: US 101, SR 87, SR 85, SR 237, I-880, I-280, I-680 (RTP ID#230248, 230404, 230254, 230259, 230258, 230278, 230280, 230264, 230263, 230256, 230257, 230270, 230272, 230281, 230275, 230260, 230276)	Santa Clara	NA	1,310,000	NA	-310,650,000	-12,520,000	-10,700,000	-240	-37.0	-160.0	-250,000	-71,000,000	
22700	Parallel corridor north of I-80 from Red Top Road to Abernathy Road (the western section extends from the railroad crossing on Red Top Road	Solano	NA	NA	NA	-7,700,000	-352,000	-266,000	-1.4	-0.8	-3.9	-5,000	-1,780,000	
94151	Construct 4-lane Jepson Parkway from Route 12 to Leisure Town Road	Solano	NA	NA	NA	2,010,000	-1,723,000	-210,000	2.8	-1.0	-0.3	-15,000	463,000	
230326	I-80/I-680/SR12 Interchange - Phase 1	Solano	NA	NA	NA	-1,289,000	-1,175,000	-734,000	-0.2	-0.3	-0.8	2,100	-300,000	
230477	SR 12 Improvements: Phase 1	Solano	NA	NA	NA	13,755,000	-732,000	-125,000	-19	0.9	6.2	4,700	3,160,000	
230496	SR 12 Improvements: Phase 2	Solano	NA	NA	NA	844,000	-297,000	-81,000	-33	0.0	0.3	4,000	194,000	
230571	I-80 EB & WB HOV Lanes (SR 37 to Red Top Rd.)	Solano	NA	-33,000	NA	3,716,400	-45,740	-34,200	-0.2	0.2	1.7	620	854,000	
230326, 230327	I-80/I-680/SR12 Interchange: Phase 1 plus Balance of Project	Solano	NA	NA	NA	7,220,000	-2,970,000	-2,570,000	1.4	-0.2	2.6	2,200	1,660,000	
230569*	I-80 EB & WB HOV lanes between Airbase Parkway and I-505	Solano	NA	-4,500	NA	22,936,000	-1,699,000	-311,000	8	1.1	10.1	1,000	5,270,000	
230570*	I-80 EB & WB HOV lanes between Carquinez Bridge and SR-37	Solano	NA	-55,000	NA	3,716,400	-228,700	-171,000	0	0.2	1.7	620	854,000	
n/a	I-80 add 5th mixed-flow lane (EB: SR-12 East to Airbase Parkway and WB: West Texas to SR-12 East)	Solano	NA	NA	NA	803,800	-251,900	-67,500	-1	0.1	0.4	2,580	185,000	
21902, 230413*	US 101 SB HOV lane extension (Railroad/ Pepper to Petaluma River Bridge)	Sonoma	NA	-44,000	NA	4,160,000	-419,000	-500,000	-4	0.7	4.0	7,140	956,000	

Note: Negative values are reductions (good), except for New Transit Riders where positive is good.

Table B-3: Monetized Impact and Costs
(in Millions of 2007$)

RTP ID#	Project Title	County	Investment Type	Transit Travel Time (in and out of vehicle)	Vehicle Hours Delay (Recurrent)	Total Recurrent Delay and Transit Travel Time	Non-Recurrent Delay	Fatality + Injury Collisions	PM2.5	PM10	CO2	Private Vehicle Operating Costs	Total Benefit	Project Capital Cost (2007$M)	NET Annual Operating Cost (2007$M)	Annualized Total Cost ($Millions)	Benefit / Cost (Cap & O&M)	Notes
22013	Eastbound I-580 Truck Climbing Lane	Alameda	NC	NA	$7.4	$7.4	$10.5	$0.0	$0.0	$0.0	-$0.2	-$0.1	$18	$64.2	$0.2	$3.4	5	
22657	I-580 (Altamont Pass) Westbound Truck Climbing Lane	Alameda	V	NA	$11.9	$11.9	$20.4	$0.0	-$0.1	$0.0	-$0.3	-$0.1	$32	$75.6	$0.4	$4.2	8	
22667	BART to Livermore: Tri-Valley rail extension from Dublin/Pleasanton BART Station to Greenville Road in the I-580 median	Alameda	NC	$112.6	$1.9	$114.5	$71.4	$0.1	$0.1	$0.0	$0.1	$1.5	$188	$1,042.0	$9.9	$44.6	4	
22671	Construct direct HOV connection between southbound I-880 to westbound Route 84 (Dumbarton Bridge approach)	Alameda	NC	$0.0	$0.5	$0.5	-$0.1	$0.1	$0.0	$0.0	$0.0	$0.1	$1	$125.0	$0.0	$6.3	0	Project is small and model may not reflect full benefits
22776	Route 84 Expressway Widening	Alameda	NC	NA	$28.8	$28.8	$58.0	$1.3	$0.4	$0.1	$0.9	$1.4	$91	$124.0	$0.7	$6.9	13	
94506	East-West Connector Project in North Fremont and Union	Alameda	NC	NA	$9.1	$9.1	$2.4	$0.1	-$0.2	-$0.1	$0.0	-$2.5	$9	$150.0	$0.6	$8.1	1	
230099	I-580/I-680 Improvements (NB I-680 to WB I-580)	Alameda	NC	NA	$18.2	$18.2	$0.6	$0.0	$0.0	$0.0	$0.0	$0.1	$19	$392.5	$0.0	$19.7	1	
230271	I-80 Express Bus Service	Alameda	NC	$5.7	$0.3	$6.0	$6.1	$0.0	$0.0	$0.0	$0.0	$0.5	$13	$70.0	$4.3	$8.2	2	
21992, 230111	AC Transit Transit Priority Measures (TPM) and Corridor Improvements* *AC Transit submitted additional TPM components consisting of Grand/Maritime HOT on-ramp and Bay Bridge contraflow lane, which are not included in this assessment. Preliminary off-model analysis suggests these components have significant benefits for transit riders and merit further	Alameda	NC/V	$19.1	$1.5	$20.6	$32.9	$0.1	$0.0	$0.0	$0.1	$2.8	$57	$38.3	$0.0	$1.9	30	
Various	Alameda HOT Corridors: I-680, I-580, I-880, I-238 (RTP ID#230088, 230089, 230609, 22042, 22668, 22664, 230241)	Alameda	NC	$11.2	$161.8	$173.0	$409.7	$18.9	$7.4	$2.0	$9.1	$43.3	$663	$1,550.9	$14.2	$91.8	7	
230419	Freeway Performance Initiative	Bay Area Region/ Multi-County	NC	NA	$361.7	$361.7	$1,242.0	-$8.9	$4.2	-$0.3	$10.0	-$15.2	$1,594	$600.0	$26.2	$56.2	28	
230369, 230610	Regional HOT Network and express bus enhancement	Bay Area Region/Multi-County	NC	$69.2	$909.9	$979.1	$2,473.0	$79.7	$33.3	$8.5	$42.7	$179.6	$3,796	$3,281.6	$44.7	$208.7	18	
22343	Express bus service expansion along I-680 corridor, Phase	Contra Costa	V	$2.0	$0.2	$2.2	$3.0	$0.0	$0.0	$0.0	$0.0	$0.3	$5	$57.0	$3.6	$6.8	1	
22346	Express bus service expansion along I-580 corridor	Contra Costa	V	$8.5	$0.0	$8.5	$0.3	$0.0	$0.0	$0.0	$0.0	$0.1	$9	$50.0	$0.5	$3.2	3	
22352	I-680/Norris Canyon Road HOV direct ramps in San Ramon	Contra Costa	NC	$0.0	-$0.2	-$0.2	-$0.1	$0.1	$0.0	$0.0	$0.0	$0.0	$0	$80.0	$0.1	$4.1	0	Project is small and model may not reflect full benefits
22400	Construct Route 239 from Brentwood to Tracy Expressway	Contra Costa	V	NA	$12.6	$12.6	$0.0	$0.0	$0.0	-$0.1	$0.4	-$1.8	$11	$200.0	$1.4	$11.4	1	
22516	Enhance Capitol Corridor regional rail service (West Contra Costa and Solano counties)	Contra Costa	V	$4.8	$2.5	$7.3	$2.0	$0.2	$0.1	$0.0	$0.1	$1.7	$11	$70.0	$5.2	$7.6	2	
22981	Widen Route 4 as continuous 4-lane arterial from Marsh Creek Road to San Joaquin County line	Contra Costa	V	NA	$3.1	$3.1	$0.0	$0.0	$0.0	$0.0	$0.1	$0.0	$3	$100.0	$0.7	$5.7	1	
94050	Upgrade Route 4 to full freeway from I-80 to Cummings Skyway (Phase 2)	Contra Costa	V	NA	$1.1	$1.1	$0.0	$3.5	-$0.8	-$0.3	-$1.0	-$5.8	-$3	$75.0	$0.5	$4.3	-1	
21205, 22350	I-680/Route 4 interchange (Phase 1, 2 and 3) and (Phases 4 and 5) and HOV flyover ramps	Contra Costa	NC/V	$0.0	$8.1	$8.1	$16.1	-$0.3	-$0.2	-$0.1	-$0.1	-$1.8	$22	$320.2	$0.6	$16.6	1	
22605, 98222, 230208	SR4 Bypass: a) Segments 1 & 2: widen from 4 to 6 lanes from Sand Creek to Balfour, and widen segment 3 to 4 lane; b) Segment 1: Route 160 freeway-to-freeway connectors to and from the north; and c) Widen from 4 to 6 lanes from Laurel Road to Sand Creek Road	Contra Costa	V/NC/V	NA	$10.5	$10.5	$1.3	$1.5	-$0.2	-$0.1	-$0.2	-$2.4	$10	$219.0	$1.7	$12.6	1	
21030	I-580/US 101 interchange improvements and new freeway-to-freeway connector from northbound US 101 to eastbound	Marin	V	NA	$1.5	$1.5	$5.6	$0.0	$0.1	$0.0	$0.1	$0.1	$7	$98.0	$0.0	$4.9	2	
230060	Marin County Local Transit Enhancement on 6 Key	Marin	NC	$3.6	$0.2	$3.8	$2.6	$0.0	$0.0	$0.0	$0.0	$0.4	$7	$27.3	$0.0	$2.0	4	
230252	Marin County Local Transit Expansion	Marin	NC	$8.7	$0.3	$9.0	$2.5	$0.0	$0.0	$0.0	$0.0	$0.6	$12	$56.0	$14.1	$18.1	1	
21902, 230413, 98154, 98147*	US 101 SB HOV lane extension (Railroad/ Pepper to Petaluma River Bridge) and Marin-Sonoma Narrows (SB: Petaluma River Bridge to Rowland; NB: north of Atherton Avenue to north of East Washington Ave)	Multi-County/ Bay Area Region	NC	$1.0	$119	$119.5	$270.0	-$0.3	-$1.3	-$0.7	-$0.1	-$8.4	$379	$926.8	$2.9	$49.2	8	
22351*	I-680 NB HOV lane extensions (North Main to SR-242 and north of Benicia Bridge to I-80) and HOV lane connector NB I-680 to EB I-80	Multi-County/ Bay Area Region	V	$0.0	$36	$36.2	$46.0	-$3.5	-$0.3	-$0.2	$0.2	-$4.2	$74	$193.0	$2.7	$12.3	6	
22415	Expand historic streetcar service	San Francisco	NC	$2.1	$0.0	$2.1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$2	$8.2	$1.1	$1.4	2	B/C is for E-line upgrade only. Does not reflect F-line extension
22420	Bus Rapid Transit (BRT)/Transit Preferential Streets (TPS) (sales tax project)	San Francisco	NC	$171.7	$8.0	$179.7	$158.0	$0.6	$0.3	$0.1	$0.3	$11.5	$350	$418.2	$0.0	$20.9	17	
230161	Van Ness Avenue BRT	San Francisco	NC	$33.4	$0.4	$33.8	$4.1	$0.0	$0.0	$0.0	$0.0	$1.7	$40	$76.1	$0.0	$3.8	10	
230164	Geary Boulevard BRT	San Francisco	NC	$61.8	$0.2	$62.0	$0.6	$0.0	$0.0	$0.0	$0.0	$1.6	$64	$190.5	$0.0	$9.5	7	
230207	Geneva/Harney Bus Rapid Tansit	San Francisco	NC	$7.8	$0.1	$7.9	$0.8	$0.0	$0.0	$0.0	$0.0	$0.3	$9	$202.0	$2.6	$12.7	1	
21612	Improvement of Dumbarton Bridge access to US 101	San Mateo	NC	NA	$20.6	$20.6	$3.8	$1.4	$0.08	$0.00	$0.9	$0.3	$27	$317.0	$0.0	$15.9	2	
21613	Route 92 improvements from San Mateo Bridge to I-280, includes uphill passing lane from US 101 to I-280	San Mateo	NC	NA	$2.8	$2.8	$7.7	-$0.5	-$0.3	-$0.1	-$0.4	-$2.1	$7	$186.2	$0.4	$9.7	1	
94644	Route 92 westbound slow vehicle lane between Route 35 and I-280	San Mateo	NC	NA	$8.1	$8.1	$0.0	$0.0	$0.1	$0.0	$0.3	-$0.1	$8	$82.0	$0.2	$4.3	2	
21714	SR 25/Santa Teresa Boulevard/US 101 Interchange (includes US 101 widening between Monterey Road and SR 25 and connection to Santa Teresa Blvd)	Santa Clara	NC	NA	$12.9	$12.9	$9.6	$0.9	$0.4	$0.1	$0.5	$1.6	$26	$233.0	$0.5	$12.1	2	
22162	Route 237 westbound to Route 85 southbound connector ramp improvements	Santa Clara	NC	NA	$1.3	$1.3	$1.7	$0.0	$0.0	$0.0	$0.0	-$0.3	$3	$37.0	$0.1	$2.0	1	
230294	New SR 152 Alignment: SR 156 to US 101	Santa Clara	V	NA	$33.9	$33.9	-$20.2	$1.2	$0.4	$0.0	$1.0	-$0.5	$16	$350.0	$1.3	$18.8	1	

Table B-3: Monetized Impact and Costs
(in Millions of 2007$)

RTP ID#	Project Title	County	Investment Type	Transit Travel Time (in and out of vehicle)	Vehicle Hours Delay (Recurrent)	Total Recurrent Delay and Transit Travel Time	Non-Recurrent Delay	Fatality + Injury Collisions	PM2.5	PM10	CO2	Private Vehicle Operating Costs	Total Benefit	Project Capital Cost (2007$M)	NET Annual Operating Cost (2007$M)	Annualized Total Cost ($Millions)	Benefit / Cost (Cap & O&M)	Notes
230403	US 101 Widening to 6-lane Freeway: SR 25 to SR 129	Santa Clara	V	NA	$9.3	$9.3	$3.1	$2.8	$0.1	$0.0	$0.0	$0.1	$15	$170.0	$0.7	$9.2	2	
22145, 22958	SR 237/US 101 improvements: a) Widen westbound Route 237 on-ramp to northbound US 101 to 2 lanes and add auxiliary lane on northbound US 101 from Route 237 on-ramp to… b) US 101 southbound to eastbound Route 237 connector improvements	Santa Clara	NC/V	NA	$7.2	$7.2	$12.6	$0.2	$0.1	$0.0	$0.3	$0.0	$20	$73.0	$0.3	$3.9	5	
Various	Santa Clara HOT Corridors: US 101, SR 87, SR 85, SR 237, I-880, I-280, I-680 (RTP ID#230248, 230404, 230254, 230259, 230258, 230278, 230280, 230264, 230263, 230256, 230257, 230270, 230272, 230281, 230275, 230260, 230276)	Santa Clara	NC	$17.6	$246.8	$264.4	$630.1	$31.5	$12.9	$3.4	$17.2	$71.4	$1,031	$777.9	$2.2	$41.0	25	
22700	Parallel corridor north of I-80 from Red Top Road to Abernathy Road (the western section extends from the railroad crossing on Red Top Road	Solano	NC	NA	$6.9	$6.9	$15.7	$0.2	$0.3	$0.1	$0.4	$1.8	$25	$68.0	$0.5	$3.9	6	
94151	Construct 4-lane Jepson Parkway from Route 12 to Leisure Town Road	Solano	NC	NA	$33.8	$33.8	$12.4	-$0.4	$0.3	$0.0	$1.0	-$0.5	$47	$182.0	$1.1	$10.2	5	
230326	I-80/I-680/SR12 Interchange - Phase 1	Solano	NC	NA	$23.3	$23.3	$43.7	$0.0	$0.1	$0.0	-$0.1	$0.3	$67	$513.0	$1.9	$27.6	2	
230477	SR 12 Improvements: Phase 1	Solano	NC	NA	$15.0	$15.0	$7.7	$2.6	-$0.3	-$0.1	-$0.3	-$3.2	$21	$100.0	$1.0	$6.0	4	
230496	SR 12 Improvements: Phase 2	Solano	NC	NA	$6.1	$6.1	$5.0	$4.5	$0.0	$0.0	-$0.3	-$0.2	$15	$150.0	$1.7	$9.2	2	
230571	I-80 EB & WB HOV Lanes (SR 37 to Red Top Rd.)	Solano	NC	$0.5	$0.9	$1.4	$2.0	$0.0	-$0.1	$0.0	$0.0	-$0.9	$2	$107.0	$0.9	$6.3	0	
230326, 230327	I-80/I-680/SR12 Interchange: Phase 1 plus Balance of	Solano	V	NA	$58.9	$58.9	$153.0	-$0.2	$0.1	-$0.1	-$0.2	-$1.7	$210	$1,183.0	$3.4	$62.6	3	
230569*	I-80 EB & WB HOV lanes between Airbase Parkway and I-	Solano	NC	$0.1	$34	$33.8	$19.0	-$1.1	-$0.4	-$0.2	-$0.1	-$5.3	$46	$132.0	$2.3	$8.9	5	
230570*	I-80 EB & WB HOV lanes between Carquinez Bridge and SR-37	Solano	NC	$0.7	$5	$5.2	$10.0	$0.0	-$0.1	$0.0	$0.0	-$0.9	$14	$105.0	$1.0	$6.2	2	
n/a	I-80 add 5th mixed-flow lane (EB: SR-12 East to Airbase Parkway and WB: West Texas to SR-12 East)	Solano	N/A	NA	$5	$5.0	$4.0	$0.1	$0.0	$0.0	-$0.2	-$0.2	$9	$69.8	$0.3	$3.8	2	
21902, 230413*	US 101 SB HOV lane extension (Railroad/ Pepper to Petaluma River Bridge)	Sonoma	NC	$0.6	$8	$8.9	$29.0	$0.5	-$0.3	-$0.1	-$0.5	-$1.0	$37	$124.0	$0.8	$7.0	5	

Table B-4: Benefits and Costs of Regional Funding Programs - Summary

Program	Approximate B/C	Alternative Performance Metric	Notes
FREEWAY PERFORMANCE	**Most direct impact on delay and only program run through regional model**		
Freeway Performance Initiative	28		
MAINTENANCE	**While B/Cs are low to average, the actual dollar value of the public savings by performing maintenance on time is huge**		
Local Streets and Roads Capital Shortfall	5	Total savings = \$9.5 B to \$39 B (Depending on level of regional investment)	B/C ratio reflects avoided increases in deferred maintenance and rehabilitation costs as well as savings in private extra vehicle operating costs incurred by driving on poorly maintained roadways, divided by the 25-year regional investment in maintenance shortfalls. Other benefits that are not accounted for here include impact that varying states of repair have on air quality, congestion, goods movement, emergency services, transit efficiency, etc...
Transit Capital Shortfall	2	Total savings = \$1.5 B to \$16 B (Depending on level of regional investment)	Reflects 1) the public benefit of avoided increases in rehabilitation and maintenance costs, and 2) the private benefit for passengers of avoided delays due to increased reliability, if transit capital assets are replaced and rehabilitated in a timely manner. Reflects only a small portion of the benefits of transit capital maintenance; does not include other benefits of maintaining an operable transit system, such as increased ridership, reduced congestion, reduced emissions, and increased mobility.
FOCUSED GROWTH	**Programs support focused growth, which reduces delay and emissions, but do not have huge, direct delay reduction benefits proportional to cost**		
Regional Bike Network	0.5		Bridge links account for approx 50% of total cost and 14% of mileage.
TLC + (recommended shift to facilitate TOD)	2		Higher VMT reduction from realignment of program to facilitate TOD. But program at this scale is still marginal compared to Focused Growth scenario tested in the Vision.
AFFORDABILITY	**Programs mainly affect amount of funding spent by low-income households on transportation**		
Lifeline	0.03		Benefits include reduction in auto-ownership costs only.
Means Based Fare Subsidy	1	Reduces transportation expenditures as share of total expenditures from 36% to 33% for households with annual income < \$15,000	Benefits include reduction in transit fare expenditures only. This is essentially a direct transfer
EMISSIONS REDUCTION	**B/Cs are low - because delay not affected, programs are most cost-effective strategies for emission reduction. The cost per emissions reduced is an order of magnitude lower than for other programs.**		
Climate Change	0.4	\$200 per ton CO2 reduced	Benefits reflect CO2 reductions only. Under other projects and programs, the cost per ton reduced is in the thousands or tens of thousands
Port Emissions/Truck Retrofit	1	\$560 K per ton PM2.5 reduced	Benefits reflect CO2 and particulate emissions only. Under other projects and programs, the cost per ton reduced is in the millions or tens of millions

Table B-5: Benefits and Costs of Regional Funding Programs - Detail

	FOCUSED GROWTH		AFFORDABILITY		EMISSIONS REDUCTION	
	Bike Network	TLC + (TOD emphasis)	Lifeline	Means Based Transit Discount	Climate Protection	Truck Emissions Reduction
COST (2007$)						
Total 25-Year Cost	$1,300,000,000	$1,500,000,000	$1,600,000,000	$1,125,000,000	$ 184,000,000	$ 106,500,000
Lifecyle of investment - for capital projects	20	20	n/a	n/a	n/a	n/a
Years of funding - for operating programs	n/a	n/a	25	25	5	8
Annual cost in 2035	$ 65,000,000	$ 75,000,000	$ 64,000,000	$ 45,000,000	$ 36,800,000	$ 13,312,500
BENEFITS - Year 2035 (unless noted)					Average Annual Benefit 2010 - 2015	Average Annual Benefit 2010 - 2018
Reduction in annual vehicle trips	14,808,400	n/a	n/a	n/a	n/a	n/a
Reduction in annual VMT (millions)	59.2	164.7	n/a	n/a	n/a	n/a
Reduction in annual total delay (VHD)	546,500	1,519,500	n/a	n/a	n/a	n/a
Reduction in annual CO2 emissions (tons)	33,800	94,000	n/a	n/a	271,200	2,200
Reduction in annual PM10 emissions (tons)	31.9	88.6	n/a	n/a	n/a	2.0
Reduction in annual PM2.5 emissions (tons)	8.7	24.3	n/a	n/a	n/a	22.8
Reduction in annual motor vehicle fatalities and injuries	33	92	n/a	n/a	n/a	n/a
VALUE of BENEFITS - Year 2035 (unless noted) in 2007$					Average Annual Benefit 2010 - 2015	Average Annual Benefit 2010 - 2018
Reduction in annual auto ownership costs (dollars)	n/a	$ 51,057,200	$ 1,798,600	n/a	n/a	n/a
Reduction in annual auto operating costs (dollars)	$ 13,612,000	$ 19,325,000	n/a	n/a	n/a	n/a
Reduction in annual transit fare costs (dollars)	n/a	n/a	n/a	$ 45,000,000	n/a	n/a
Reduction in annual delay (VHD)	$ 10,706,000	$ 29,767,000	n/a	n/a	n/a	n/a
Reduction in annual CO2 emissions	$ 2,366,000	$ 6,580,000	n/a	n/a	$ 13,035,000	$ 157,000
Reduction in annual PM10 emissions	$ 676,000	$ 1,879,000	n/a	n/a	n/a	$ 42,000
Reduction in annual PM2.5 emissions	$ 3,057,000	$ 8,500,000	n/a	n/a	n/a	$ 7,981,000
Reduction in annual motor vehicle fatalities and injuries	$ 4,412,000	$ 12,267,000	n/a	n/a	n/a	n/a
SUMMARY						
Total Benefit - Year 2035 in 2007$	$ 34,829,000	$ 129,375,200	$ 1,798,600	$ 45,000,000	$ 13,035,000	$ 8,180,000
B/C Ratio (rounded, if rounds to 1 or higher)	0.5	2	0.03	1	0.4	1
Cost per milllion VMT Reduced	$ 1,097,000	$ 455,000	n/a	n/a	n/a	n/a
Cost per Ton CO2 Reduced	$ 1,900	$ 800	n/a	n/a	$ 200	$ 6,100
Cost per Ton PM10 Reduced	$ 2,040,100	$ 846,700	n/a	n/a	n/a	$ 6,713,800
Cost per Ton PM2.5 Reduced	$ 7,441,500	$ 3,088,300	n/a	n/a	n/a	$ 583,800

Table B-6: Transit Projects Ranked by Cost per Low-Income Household Served [1]

RTP ID	County	Title	Investment Type	Total Capital Cost (M 2007$)	Annualized Capital Cost (M 2007$)	Annual Net O&M cost (M 2007$)	Total Annualized Cost (M 2007$)	Low-Income Households Served in 2035	Annualized Cost/ Low Income Household	Notes
21992 and 230111	Alameda	AC Transit Transit Priority Measures (TPM) and Corridor Improvements	NC & V	$38.3	$1.9	$0.0	$1.9	114,939	$17	
22420	San Francisco	Bus Rapid Transit (BRT)/Transit Preferential Streets (TPS) (sales tax project)	NC	$418.2	$20.9	$0.0	$20.9	69,562	$301	
230161	San Francisco	Van Ness Avenue BRT	NC	$76.1	$3.8	$0.0	$3.8	11,860	$321	
230271	Alameda	I-80 Express Bus Service	NC	$70.0	$3.9	$4.3	$8.2	15,484	$528	
22415	San Francisco	Expand historic streetcar service	NC	$8.2	$0.4	$1.1	$1.5	2,424	$633	E-line upgrade only. Does not reflect F-line extension
230164	San Francisco	Geary Boulevard BRT	NC	$190.5	$9.5	$0.0	$9.5	10,098	$943	
230060	Marin	Marin County Local Transit Enhancement on 6 Key Corridors	NC	$27.3	$1.4	$0.0	$1.4	896	$1,523	
230207	San Francisco	Geneva/Harney Bus Rapid Tansit	NC	$202.0	$10.1	$2.6	$12.7	3,126	$4,047	
230252	Marin	Marin County Local Transit Expansion	NC	$56.0	$4.0	$14.1	$18.1	1,957	$9,239	
22343	Contra Costa	Express bus service expansion along I-680 corridor, Phase 2	V	$57.0	$3.2	$3.6	$6.8	668	$10,190	
22516	Contra Costa	Enhance Capitol Corridor regional rail service (West Contra Costa and Solano counties)	V	$70.0	$3.5	$5.2	$8.7	535	$16,318	
22346	Contra Costa	Express bus service expansion along I-580 corridor	V	$50.0	$2.8	$0.5	$3.2	97	$33,397	
22667	Alameda	BART to Livermore: Tri-Valley rail extension from Dublin/Pleasanton BART Station to Greenville Road in the I-580 median	V	$202.0	$10.1	$9.9	$20.0	0	NA	

[1] Low-Income household served is defined as the number of transit-riding low-income households within 1/2 mile walkable distance of transit stops
[2] NC indicates project was proposed as a "New Commitment" for the financially constrained portion fo the plan; V indicates project was proposed for the unconstrained, "Vision" portion

Table B-7: Households Within 1/2 Mile Walking Distance of Transit Stops

RTP ID	County	Title	Investment Type [1]	Number of stops	Total Households	Low-Income Households	Transit Using Households	Low-Income Transit Using Households
21992 and 230111	Alameda	AC Transit Transit Priority Measures (TPM) and Corridor Improvements	NC & V	406	597,700	284,200	222,100	114,900
22420	San Francisco	Bus Rapid Transit (BRT)/Transit Preferential Streets (TPS) (sales tax project)	NC	1,085	340,000	130,800	185,700	69,600
230161	San Francisco	Van Ness Avenue BRT	NC	10	45,800	21,800	25,600	11,900
230271	Alameda	I-80 Express Bus Service	NC	316	74,900	36,700	28,600	15,500
230164	San Francisco	Geary Boulevard BRT	NC	12	47,500	18,900	26,400	10,100
230060	Marin	Marin County Local Transit Enhancement on 6 Key Corridors	NC	172	18,600	5,100	3,300	900
22415	San Francisco	Expand historic streetcar service	NC	12	15,400	4,600	8,700	2,400
230207	San Francisco	Geneva/Harney Bus Rapid Tansit	NC	18	14,300	6,100	7,300	3,100
230252	Marin	Marin County Local Transit Expansion	NC	460	36,900	11,100	6,500	2,000
22343	Contra Costa	Express bus service expansion along I-680 corridor, Phase 2	V	52	10,700	2,300	3,200	700
22516	Contra Costa	Enhance Capitol Corridor regional rail service (West Contra Costa and Solano counties)	V	3	2,500	1,800	700	500
22346	Contra Costa	Express bus service expansion along I-580 corridor	V	8	1,700	500	400	100
22667	Alameda	BART to Livermore: Tri-Valley rail extension from Dublin/Pleasanton BART Station to Greenville Road in the I-580 median	V	2	0	0	0	0

[1] NC indicates project was proposed as a "New Commitment" for the financially constrained portion fo the plan; V indicates project was proposed for the unconstrained, "Vision" portioi

Table B-8: Regional Conversion Factors and Valuation Assumptions for Regional Programs
Updated 4/30/08

Conversion Factors in 2035

Total delay VHD/million VMT (recurring & non-recurr	9,227
Recurring delay VHD/million VMT	6,846
CO2 emissions tons/million VMT	571
PM10 emissions tons/milllion VMT	0.54
PM2.5 emissions tons/million VMT	0.15
Motor vehicle fatalities and injuries/million VMT	0.56

Source Data

Average Weekday in 2035	
Regional VMT	177,671,400
Regional Delay (VHD recurring + non-recurring)	1,639,300
Regional CO2 emissions (tons/day)	101,404
Regional PM10 emissions (tons/day)	95.6
Regional PM2.5 emissions (tons/day)	26.2
Regional motor vehicle fatalities and injuries (daily)	99

Source: Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan
Vision 2035 Analysis Data Summary (November 2007, tables F and G); values are for the Year 2035 Baseline forecast
Baseline (rather than investment alternative) recommended since regional programs are relatively modest in scale
and not closely tied to any of the tested investment scenarios

Motor vehicle fatalities and injuries based on 3/2008 No Build forecast as shown below:

3/08 Forecast AM Peak VMT	26,088,160
AM to daily conversion factor	6.7
Converted Daily VMT	174,790,670
3/08 daily VMT forecast as pct of 11/07 forecast	98%
Additional Adjustment factor	102%
3/08 Forecast AM Peak injuries and fatalities	14.53
Estimated daily injuries and fatalities	98.96

Vehicle Operating Costs	**cents**
Cost per VMT in 2035 (in 1990$)	14.1
1990 CPI	132.1
2007 CPI	215.3
Adjustment factor (2007/1990 CPIs)	1.63
Cost per VMT in 2035 (in 2007$)	23.0

Valuations in 2035 (2007$)

Travel time (recurrent congestion)	$	19.59	per vehicle hour	assumes 1.42 average vehicle occupancy
Travel time (non-recurrent congestion)	$	58.76	per vehicle hour	and average 4% trucks
Accidents (average fatal+injuries)	$	133,737	per collision	assumes 1.6% of collisions are fatal
PM2.5	$	350,000	per ton	
PM10	$	21,216	per ton	
Value of CO2 in 2035	$	70.00	per ton	
Value of CO2 in 2015	$	48.06	per ton	

Sources:
Travel time (recurrent congestion) - one half the hourly mean wage rage for the Bay Area region. Assmes average vehic
occupancy of 1.42 and average of 4% truck traffic. Value of truck travel time is based on wage data
from the Bureau of Labor Statistics.
Travel Time (non-recurrent congestion) - three times value for recurrent congestion, per FHWA guidance
Accidents - from 2005 Collision Data on State Highway (Caltrans). Includes direct costs (e.g., property repair), lost work time
and willingness to pay to avoid injury
Particulate emissions - Reflects health impacts. Reflects data specific to the Bay Area
Carbon dioxide - Based on guidance issued by the UK Department for Environment, Food and Rural Affairs, which is based
on the Stern Review (2006). Reflects the full cost of a unit of emissions over its lifetime. Under this method,
later reductions are worth more, as the concentration of CO2 is projected to rise over time.
More discussion of valuations is documented in Preliminary Quantitative (Benefit-Cost) Evaluation Summary and Methodology

METROPOLITAN
TRANSPORTATION
COMMISSION

Joseph P. Bort MetroCenter
101 Eighth Street
Oakland, CA 94607-4700

510.817.5700 PHONE
510.817.5769 TDD/TTY
info@mtc.ca.gov E-MAIL
www.mtc.ca.gov WEB